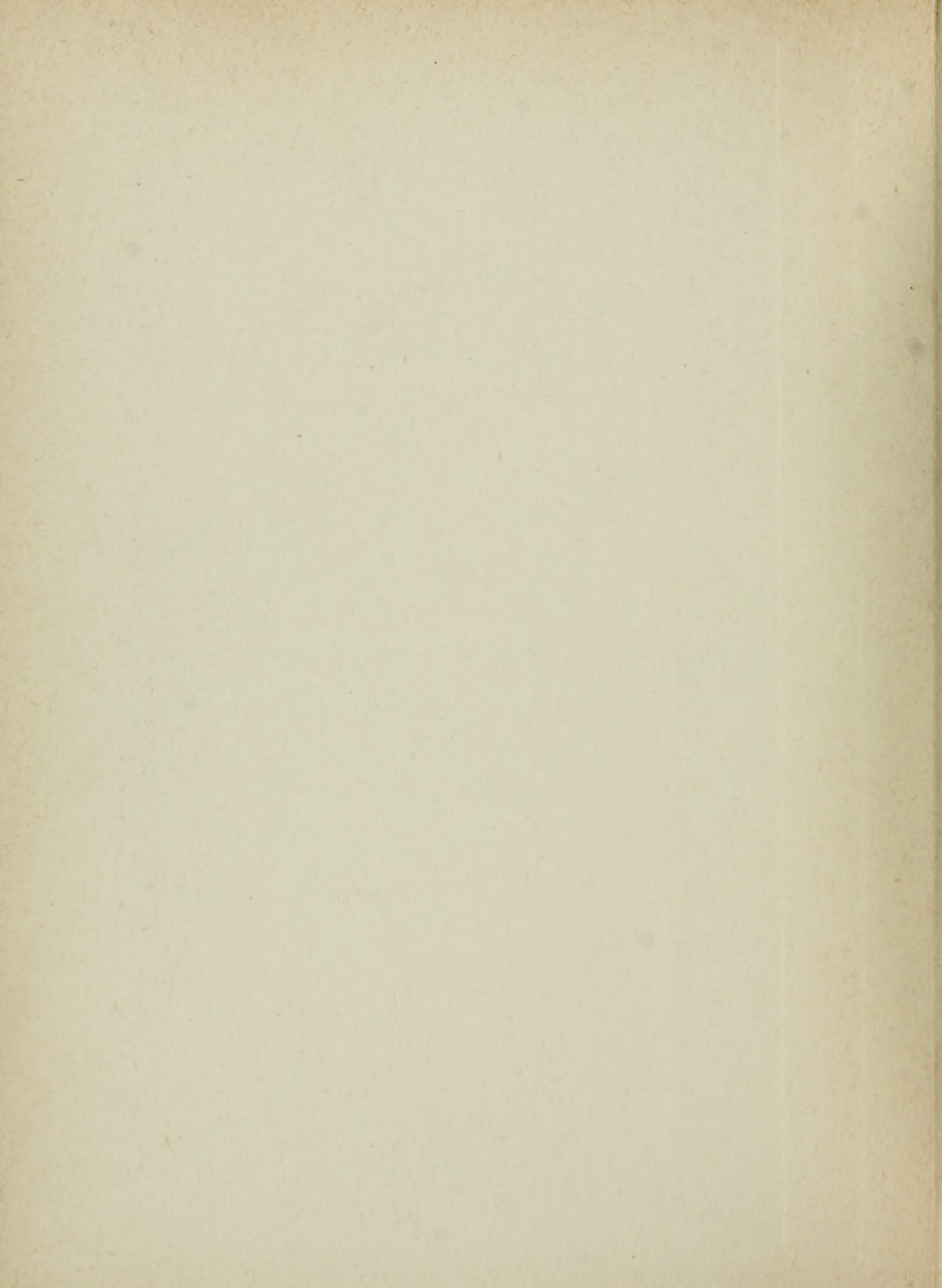






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The Place Value of the Waterpowers of the Pacific Coast for Electrochemical Industries

In this issue we publish a very readable, enthusiastic and decidedly sensible paper by Mr. John Wood Beckman on electrochemical possibilities of the Pacific Coast states. This paper gives us a welcome opportunity to discuss in a few words the relative value of waterpowers in different localities. Waterpowers have been very much talked about recently. With what has been said about the urgent need of removing the unwise and directly foolish legal restrictions which hamper the development of American waterpowers at present in the most serious manner, we fully agree. But we are somewhat under the impression that the owners of waterpowers in different parts of the country, together with the commercial interests depending on them, have not always taken a scrupulously correct attitude toward each other. There have been some indications of jealousy or, shall we say, provincialism. It is perfectly natural that the owner of a waterpower thinks that his own waterpower is the most important. It certainly is for him. But we don't see the slightest justification for such jealousy as is natural between competitors in other lines. The reason is simply that as things are there can be very little competition between different waterpowers. The sphere of usefulness of a waterpower as potential producer of an electrochemical product can be accurately figured from the cost of power and of raw materials, operating cost, selling price and the very important item of freight charges from waterpower to market. Any waterpower has its own restricted market beyond which it cannot extend its usefulness economically, and it will be found that the market zones of the most important waterpowers overlap very little. All that is really needed in order to convince oneself of the truth of this statement is to tabulate the freight-rates from any one waterpower to the principal industrial centers of this country.

To give one concrete example which is rather extreme, we may refer once more to the present power famine in Niagara Falls. In order to find a remedy, it would be plain foolishness to think that the abundant and relatively cheap waterpowers of the Pacific Coast could be used as a substitute for Niagara power to supply the principal markets now supplied by the Niagara Falls electrochemical industries. The freight rates from the Pacific Coast to the manufacturing districts of the East and Middle West are prohibitive. Competition in this market between electrochemical products from Niagara power and from Pacific Coast power is therefore an economic impossibility. But has anyone ever seriously suggested this? Mr. Beckman's paper

is just one more proof that the Pacific Coast clearly understands the situation and looks out for its own market. But if there cannot be commercial competition why should there be not a real attitude of mutual helpfulness between the waterpower interests of the East and the West?

There is a very simple fundamental reason why freight rates are of such enormous importance in determining the selling zone of a waterpower as an electrochemical producer. It is a well-known fact that the usefulness of so many electrochemical products is due to the stored energy in them. In other words, that the sale of so many electrochemical products is a case of chemical power transmission. But chemical power transmission, unlike electrical power transmission, depends on ordinary transportation means—railroads, ships, etc.—and this fact makes freight rates all important in chemical power transmission. And this is even more so in this country than abroad. In our issue of March 15, 1916, in discussing the place value of waterpowers, we gave indisputable figures showing that while this country is easily the foremost industrial nation, in that it has succeeded in multiplying the natural working productiveness of its average citizen by industrial development, yet, on the other hand, this country is very much less industrially populated than England or Germany, and the cost of transportation between the different industrial centers among each other and between industrial centers and sources of raw materials and markets respectively is very much greater. This consideration explains why in the chemical industries certain things are possible in Germany which are impossible in this country. It also explains why Niagara's unique position among American waterpowers is, to a large extent, due to its connection to the Great Lakes, with 3600 miles of shore line and navigable to the very docks at Niagara. The least expensive sort of transportation is thus provided for Niagara products to markets representing nearly half the population of North America, while the least expensive supply of raw materials is provided in many cases by the same waterway, quite aside from the railroads running from Niagara in all directions.

Now, what are the possibilities of electrochemical industries on the Pacific Coast? Mr. Beckman discusses this very question in an interesting way by basing his discussion on certain analogies between the conditions of the Pacific Coast and those of Sweden and Norway. Of course, the Pacific Coast States themselves offer at the start a ready market for electrochemical products, and this market will grow, but it is not large enough, nor will it be large enough for a long time to come in order to absorb all the products that could be made with the immense waterpowers available and waiting for development. Mr. Beckman is right: the Pacific Coast will have to follow the lead of Sweden and Norway and look for export trade and learn "the art of handling tramp steamers." "We can reach from the Pacific Coast over one-half of the world's population by going west and south. Some of the markets are small, but they are bound to grow, and if we miss

the present opportunity somebody else will step in and collect the harvest which legitimately belongs to us."

Clearly, there are almost unlimited possibilities. But the amount of work that remains to be done to transform this vision into a reality is immense. Yet the pioneer spirit of the people of the Pacific Coast is just fitted for the task. When once the problem and the opportunities are realized; when, as Mr. Beckman puts it, an "electrochemical atmosphere" has been created, it may be safely left to the people of the Pacific Coast themselves to do the rest. The Pacific Coast has undoubtedly more potential wealth in its 11,000,000 hp. of waterpower, of which 93 per cent now goes to waste, than in all the gold that was ever mined or is still to be mined in those States. But an export trade must be created. The Golden Gate will then become the gate to a new and glorious future of the empire of the Pacific Coast.

Labor and Prosperity

The wages of men engaged in the production of the base metals are now quite generally based on the market price of metals, with a sliding scale that automatically adjusts wages to changes in the market. This arrangement has prevailed in the copper industry for several years, and has been adopted in some measure in the case of lead and zinc. Wages at the present time are accordingly much higher than before the war, due to the increased price of metals.

Assuming a fair and reasonable base wage and rate of increase, the idea is equitable and commends itself as a just means of insuring harmony and contentment. It appeals to the wage earner, particularly as long as prices rise and wages increase; but he takes a reverse situation with bad grace, even though it is still fair and equitable. Becoming accustomed to unusual prosperity, he seems to accept it as a standard condition and regards any unfavorable change as an encroachment on his established rights. He is not what is called a good loser, even though as a matter of fact he loses nothing except as the operator also loses. Labor may not be insincere in accepting sliding wage scales, but it shows moral incapacity when called upon to take reverses.

In the Joplin district wages for a certain class of labor were based at \$3.50 per day when zinc concentrate sold between \$50 and \$60 per ton, with an increase of 25 cents per day for each increment of \$10 in the average price of concentrate above the \$60 limit. Several times the operators have paid a 25-cent increase when the average price of concentrate for a month exceeded one of the \$10 limits by narrow margins of less than \$1. Recently when the average price of concentrate fell below one of the limits by only \$1.88, labor not only objected to the corresponding cut in wages, but demanded an increase of 25 cents per day over the current wage. Failing to get the increase, they threatened a strike.

Instances could be multiplied to show the unreasonableness of men after temporarily enjoying unusual advantages. It is a human trait and not a peculiar characteristic of prosperous labor, but it crops out in a most unfortunate way in the latter class and brings merited

condemnation. A little more reason, appreciation and sense of moral obligation would fortify labor's position in a marked degree.

A Scientific Tariff for Steel?

It is a fortunate thing for the iron and steel industry that both political parties are committed to the principle of a tariff commission. Both now carry the idea as a platform plank, and the party in power is enacting a tariff commission bill into law.

One may rejoine that the mere expectation that some sort of a tariff commission, with unknown personnel, is to be established, is narrow ground on which to congratulate the steel industry, but things must be considered in their relation. There could be nothing worse than the tariffs the country has had, or the methods by which they were constructed, or the utter abandon with which they have been modified. The condition has been so bad that practically any step would be a step toward better things, if not a step in precisely the right direction.

A tariff commission should be able to produce, eventually, a scientific tariff. It would be able to proceed upon known facts, as it gathered the facts, but that is only one feature. Hitherto the tariff has been revised simply as political need or political opportunity presented itself, the facts as to the course of trade, the volume of our imports or the volume of our exports of a given commodity having nothing to do with the determination of the party controlling the Congress to revise the tariff.

One of the things a tariff commission would necessarily do would be to study the working of the existing tariff, observing what material it let in and what material it kept out, then endeavoring to determine whether the flow of material, or lack of flow, was for the best interests of the country. A conclusion that the condition as to the specific commodity was not the best possible would result in a recommendation that the tariff should be modified. Thus developments in commerce, not developments in politics, would determine when and how the tariff should be modified. It is rather an elementary proposition that the tariff should be controlled by such influences, but there are various elementary principles that have thus far been ignored in the conduct of the Federal government.

That a tariff commission principle in the making of Schedule C of the tariff is particularly welcome at this time to the steel industry is due to the mental position of the steel industry itself. Hitherto the steel manufacturers have appeared at least to know what they wanted. As individuals they have expressed strong convictions in hearings of the Ways and Means Committee of the House and the Finance Committee of the Senate. It is true the convictions of the various individuals did not always harmonize, largely from insufficient rehearsal, one may surmise, but the fact remains that the steel men have claimed to know what they wanted. They even cited figures to prove it.

Now their position is different. There are no competitive conditions now. We are shipping steel to certain countries that formerly tried to get into our own

domestic market, and would gladly ship steel, if conditions permitted, to one country that has been the greatest steel exporter of all. American steel manufacturers do not know what competitive conditions will be like after the war. There are speculations of various sorts. Everything is uncertain. No one could determine now what rates would be best. What is needed is a system whereby the tariff rates will be quickly and sensitively responsive to conditions that develop when the war ends. To create and maintain such a tariff the commission seems the best that could be adopted. The establishment of the commission will be only the veriest beginning. A tremendous responsibility will rest upon it, and in its conduct there should not be too much of the "celerity contempered with cunctation" referred to by a recent governor of Pennsylvania.

War Prices, Smelting Schedules and Profits

We have become so accustomed to linking the war price of metals with high profits to producers that it is an anomaly to find a company that is not as prosperous under present conditions as it was a year ago with a normal metal market. One such case has come to our notice, and probably it could be duplicated. The company ships a concentrate containing lead, copper and silver, to the local plant of a large lead-smelting concern. The schedule of rates and charges is the one generally in force in a district of comparatively small mines and companies.

Comparing profit from shipments to-day and a year ago, a strange situation is revealed. On a recent shipment made when lead, silver and copper were quoted at abnormally high prices, 48 per cent of the gross market value of metals in concentrates was absorbed by the smelter, leaving the shipper 52 per cent. A year previous, when metals were at a much lower price, concentrate of about the same grade was shipped, but only 39 per cent of the gross market value of the metals was absorbed by the smelter, leaving the shipper 61 per cent. When the net return under the high price of metals was figured back to profit per ton of crude ore, the slight increase over a year ago was found insufficient to offset the greater cost per ton of labor, powder and other supplies.

In another case the shipper received only 49 per cent of the gross market value of the metals, figuring silver at 64 cents, lead at 7 and copper at 27, or \$22.67 per ton. Calculating the return from the same concentrate under normal prices for metals, say silver at 53 cents, lead at 4 and copper at 14, the return to the shipper would have been \$16.85. In other words, with silver advanced 11 cents per ounce, and lead and copper all but doubled in market value, the net increase to the shipper was but \$5.82 cents per ton, or only about one-third more than he would have received at normal prices.

Two elements combine to produce this condition. The first is the obvious increase in the cost of operation. The second is the nature of the smelting schedule, which, while it is designed to encourage production when metal prices are low, enables the smelter to reap most of the benefit when they are high.

Readers' Views and Comments

The Time Factor and Catalysis in Human Affairs

To the Editor of Metallurgical & Chemical Engineering

Sir: Things are not going right in public affairs. Some features seem to be getting into the way of betterment, although the process appears almost imperceptible to the naked eye. For instance, in New York City there are thousands of children of school age that are unable to secure school accommodations. And yet, under the Wirt system, with some additional equipment, every child in New York could enjoy full school time and there would be facilities to spare. On the Board of Education there are earnest and sincere men of constructive mind and disposition. But the whole thing is tangled up with politics, the mayor lacks power, vested rights in the form of somebody's prospective profits stand in the way—and the children are growing up on the streets. There is money enough, there are schools enough, there is, indeed, everything in plenty except intelligence and character in a small part of the Board of Education—and time. A part of the board plays politics and holds back progress, but the board, as a whole, is intelligent enough. Trouble is, the city is too big, the board is too big and the whole system is too big to do anything at once. It looks as though New York would have a good public school system in time, but many children of the present generation are growing up just where they should not grow up.

A recent issue of "Commerce and Finance"—a very readable paper withal—tells under "Grafting on the State" the findings of the Brooklyn Young Men's Republican Club in regard to the expenditures of the representatives of the State of New York in connection with the Panama-Pacific Exposition. It was a little matter of \$700,000. First there was a handsome temporary building put up that housed no exhibits. Dishes, silverware and glasses from Tiffany's cost \$5168.25. Various banquets given there cost over \$2000 each. Three New York State commissioners took trips to Europe "to get into touch with exhibitors" to no real purpose whatever. Any number of State officials and commissioners having nothing to do with the exposition took trips to California and back with their entire families—and charged everything to the pork barrel. A gentleman of the commission spent some time at Hotel Knickerbocker in New York and his expense account for three days was: Room, \$21; restaurant, \$63.03. It all came out of taxes.

For the week previous his expenditures were more modest, being as follows:

Feb. 14:	Breakfast..	\$4.85	Lunch..	\$4.90	Dinner..	\$7.85
" 15:	"	4.65	"	4.75	"	7.60
" 16:	"	4.10	"	5.25	"	7.45
" 17:	"	4.85	"	4.80	"	9.10
" 18:	"	4.20	"	3.90	"	7.80
" 19:	"	3.85	"	4.10	"	7.80
" 20:	"	4.10	"	...	"	7.90

all of which was charged up.

A dinner to the Hon. Seth Low cost \$2402—at least that sum was charged to the State of New York for it, and we know that Mr. Low is the last man on earth to approve of that sort of thing. We doubt if he had knowledge that it was not a subscription dinner. For Governor Whitman and his suite a special train was chartered. The cost to the State was over \$1000 a day, for twenty-four days.

Every member of the party ate over \$25 worth of

food per day—if the figures are correct. That is what the State of New York paid for. Now there are many State commissions that do nothing but junket on money gathered from taxes, but there are others, permanent ones, that are so well manned, that do such good work, and at such cost of time to the really able men who constitute them, that the waste of their unscrupulous colleagues is neutralized. In time such scandalous proceedings as the debauch of the Exposition Commission will cease. Trouble is, New York is a big State, and it takes time to get over these things. Time and then something else.

Some time ago reference was made in "Metallurgical & Chemical Engineering" to the present Congress, and it was noted that during the first seven days of its session there were many bills introduced of which 5 per cent were for the public welfare and 95 per cent were designed chiefly to give public money to private persons. The history of Congress since then has been very little better. We want so much from it in the way of progressive legislation that it would seem to be the part of wisdom to placate the gentlemen with kind words. We do not hesitate to say that there are some men there who deserve all praise, and who hold aloft ideals of patriotism and integrity in a way to do us all proud. To them we accord all praise. But Congress is not wholly made up of that sort. A large number of its members are loud-mouthed shysters and pettifoggers who are too blind to see, too stupid to think, too selfish to feel and totally unworthy to be intrusted with public affairs. The type of men that we, as citizens, have allowed to creep into elective offices without a protest is a shame to all of us. And unless an enlightened public conscience arises in its might and drives the men of subnormal character out of elective offices, there will be no better chance for decent business in this country than there is in Mexico. This is the part that is up to us as electors. Congress, as we have said before, is US, the people. It reflects *our* intelligence. If we improve in intelligence and character, so will Congress. If we drop off, Congress will increase in noise and decrease in mind. But whatever happens, owing to the great mass of people and the number of their representatives, the process is bound to be slow; very, very slow.

The time factor, however, is not stable. It is subject to remarkable acceleration by the catalytic action of public opinion. As soon as the public learns, for instance, that many millions of dollars of Uncle Sam's money is to be spent by State officials on, let us say, militia, and that without any adequate check upon the way in which it is to be expended, the State officials will have to produce the goods—will deliver soldiers instead of politicians with epaulettes and men who play at drill once a month.

If the income tax, for instance, touched small incomes, no matter how slightly, the chances are that public opinion would be aroused and the time factor in the elimination of graft would be reduced in an amazing measure. Catalysis in human affairs is a very interesting subject.

X. Y.

The National Fertilizer Association will hold its twenty-third annual convention, together with the Southern Fertilizer Association at the Homestead, Hot Springs, Va., July 10 to 14.

Cleveland Meeting of American Institute of Chemical Engineers

The eighth semi-annual meeting of the American Institute of Chemical Engineers, held in Cleveland, Ohio, from June 14 to 17, 1916, proved very enjoyable. It was probably the best attended meeting the Institute has held so far, while the local committees had provided an excellent program of entertainments.

WEDNESDAY MORNING SESSION

The opening session was held in the Hotel Statler on Wednesday morning, June 15. The attendance at this session varied between 50 and 75. As President Rosengarten was unable to attend on account of a serious automobile accident, the meeting was called to order by Professor J. H. JAMES.

In his address of welcome Mr. RALPH L. FULLER, president of the Chamber of Commerce and vice-president of the Harshaw, Fuller & Goodwin Co., called attention to the large number and the variety of chemical industries in Cleveland and vicinity. He emphasized that these industries were in sore need of a protective tariff in view of the conditions likely to be met with after the war. He suggested the advisability of a concerted effort by the American Institute of Chemical Engineers and similar organizations toward securing adequate and effective protection for the chemical industries which have been started or largely expanded during the last few years to meet present conditions.

Secretary JOHN C. OLSEN of the Institute replied to Mr. Fuller and expressed his appreciation of the fact that the Institute had been welcomed to Cleveland by a chemical engineer and manufacturer equally familiar with technical and business problems. He thought the suggestion of the Institute taking active steps to endeavor to secure suitable tariff legislation was feasible.

The report of the treasurer, Dr. F. W. Frerichs of St. Louis, Mo., showed a very substantial balance on hand. The secretary reported that 27 applications for membership had been received since the winter meeting and nine new members had been elected.

The Committee on Meetings reported that invitations for the next winter meeting had been received from St. Louis and New York. New York appeared to be favored by those present.

A progress report was presented by the Committee on Patents of which Dr. Baekeland is chairman.

Two technical papers were then read and discussed. Professor JOSEPH W. RICHARDS presented a paper on "the production of the rarer metals." This paper, which was of especial interest on account of various suggestions as to the lines along which improvements in the manufacture of the rarer metals are possible, is printed in full elsewhere in this issue.

In a paper by Professor E. E. WARE and R. E. CHRISTMAN on "the effect of storage on mixed paints" it was shown that deterioration in mixed paints is frequently due to the presence of zinc oxide.

WEDNESDAY AFTERNOON EXCURSIONS

On Wednesday afternoon the Central Furnaces and the Semet-Solvay by-product coke-oven plant of the Cleveland Furnace Company were visited. The melting of the steel in open-hearth furnaces (of which there are 100 of 50-ton capacity), heating in soaking pits and passage through the rolling mills were seen. In order to obtain a uniform product, two mixers of 400 tons capacity are used. The Garrett continuous rod mill was inspected with interest, also a Bessemer converter in operation.

At the Semet-Solvay plant a bank of 100 ovens of 800 to 1000 tons daily capacity was inspected. Ammonia and light oils are recovered from the gas which is worked with petroleum to recover the light oils.

WEDNESDAY EVENING SESSION

The evening session was held at the University Club, Professor J. H. James presiding.

The first paper presented dealt with "nitric acid sophistication," the author being Professor JAMES R. WITHROW. The examination of a shipment of nitric acid from which crystals of sodium nitrate had been deposited was the occasion for a study of the solubility of sodium nitrate in nitric acid of various strengths. It was found that as much as 6 per cent of this salt could be dissolved producing a considerable increase in specific gravity. The presence of considerable amounts of calcium chloride in muriatic acid was reported during the discussion.

A paper by Mr. HERMAN STABLER of the U. S. Geological Survey, on "water powers of the Western United States," gave a list of water powers which have been developed in the Western states, aggregating 1,396,000 hp. Most of this power is used for electric lighting, electric traction and general municipal purposes, but not for electrochemical industries. A list of possible developments aggregating 5,708,000 hp. was given.

In the discussion of this paper it was brought out, especially by Mr. F. A. LIBBURY, that on account of cost of transportation electrochemical industries cannot be located west of the Mississippi to supply the market of the East and Middle West. On account of the limited amount of power available at Niagara Falls electrochemical industries cannot expand there and are being relocated in Canada, France or Norway.

After the reading of the papers the members were entertained as guests of the local committee at a highly pleasant smoker with a musical program.

THURSDAY EXCURSION

Thursday morning the members were taken by automobile to the ore docks of the Pennsylvania R. R. Much interest was shown in three Hulett unloaders which were transferring the ore from an ore boat to railroad cars. The capacity of the buckets is 17 tons. The best record for unloading an 11,800-ton boat is 3 hours and 35 minutes, including weighing and loading on cars; the usual time is 4 hours.

The Cleveland filtration plant was then visited. This plant is built for the treatment of 85 million gallons of water. The purification consists of precipitation and clarification with ferrous sulphate, sedimentation, rapid sand filtration and chlorination. Mechanical sand filters are installed.

The plant of the National Carbon Co. was then visited. Dr. W. C. Moore guided. At this plant the manufacture of electric arc carbons was inspected, special interest being shown in the carbons used for the flaming arc lamps. Interest was also shown in the brushes for electric dynamos. Fifty grades are being manufactured. The methods in use for testing these brushes were shown. The manufacture of dry cells and methods of testing were also shown.

Luncheon was served at the Case School of Applied Science, an address of welcome being made by Prof. F. A. MABERY, who gave a short account of the formation and development of the school. Secretary Olsen responded, stating that the chemical engineers recognized that the varied chemical industries of Cleveland owed much of their prosperity and existence to Case School, which had furnished the technical men who carried on the industries.

LECTURE ON SOUND

After luncheon the chemical engineers were entertained and instructed by an admirable lecture by Prof. D. C. MILLER on "sound." Special interest was shown in the phonodyke, an instrument devised and built by Dr. Miller by which the curve of any sound may be thrown on the screen. The audience was delighted to watch the ever-varying curves produced by the music of a phonograph as well as those produced by the cheers and encores which greeted Prof. Miller's wonderful achievement. The sound waves were magnified 40,000 times. The mirror of the phonodyke weighs 2 milligrams and can vibrate 12,000 times per second.

The physical and chemical laboratories were then inspected with great interest.

DINNER

The subscription dinner was held in the evening in the beautifully decorated library of Hotel Statler. About 65 were present. Prof. A. W. SMITH acted as toastmaster, introducing first Dr. WILLIAM C. MOORE, chairman of the local section of the American Chemical Society, who spoke of the work of the local chemists. Mr. F. H. LEE, of the Grasselli Chemical Co., and chairman of the local committee of arrangements for the meeting, spoke of the efforts of his committee to make the visitors welcome. Dr. T. B. WAGNER was introduced as the only ex-president of the Institute present at the meeting and amused the party by telling of his efforts to be relieved of the duties of being ex-president. Mr. JOHN C. HEBBEN related his experience in building the plant of the Federal Dyestuff and Chemical Co. at Kingsport, Tenn., which is now in successful operation. Prof. A. H. WHITE told many amusing stories and spoke very interestingly on progress in chemical engineering education at the University of Michigan. Secretary J. C. OLSEN, in a toast to the "Institute," emphasized the substantial growth of the Institute and its bright prospects for the future.

FRIDAY EXCURSIONS

On Friday the members were taken by automobile to the National Lamp Works of the General Electric Co. at Nela Park where incandescent lamp bulbs are blown. The glass furnaces were inspected and the clean and orderly condition of the entire plant was greatly admired. The time of blowing a bulb was found to be 20 seconds. The Smith gas producer used in the plant was then inspected.

The cutting and decorating of the globes was then shown as well as the method of testing the bulbs not only for life of the bulb, but also for candle power. Interest was shown in the photometric room, which is one of the best equipped in the world. Tests are made of the light emitted by the lamp at any angle with an accuracy of one-tenth of one per cent.

The research laboratories were then visited, where methods of producing artificial day light were shown.

FRIDAY AFTERNOON SESSION

The company then proceeded by automobile to the Country Club, where an elaborate lunch had been arranged for by the Grasselli Chemical Company in honor of the visiting chemical engineers.

After luncheon an illustrated lecture was given by Prof. EDWARD BARTOW on the experiments on purification of sewage by activated sludge which have been carried out at the University of Illinois. Analyses of the gases evolved show considerable oxidation of the carbon in the sewage.

The Cleveland experiment sewage disposal plant was then visited. Mr. R. Winslow Pratt acted as guide.

A one million-gallon unit for the purification of sewage by means of activated sludge is in operation. The sewage is subjected to the air for about one hour, $\frac{3}{4}$ cu. ft. being used per gallon of sewage. The raw sewage contains about 98 parts of iron per million gallons. This iron is precipitated, giving the sludge a brown appearance. The sludge contains about 3.5 per cent nitrogen, 2 per cent phosphorus pentoxide, 0.23 per cent K_2O and 7 per cent fat.

FRIDAY EVENING SESSION

On Friday evening a joint meeting with the Cleveland Section of the American Chemical Society was held at the Hotel Statler, Dr. T. B. WAGNER presiding. A paper on "acid-resisting alloys" by W. C. CORNELL was read and discussed at considerable length, Mr. F. A. LIDBURY spoke on "the electrochemical industries of the United States," and the report of the Committee of the New York Section of the American Chemical Society on Co-operation between Universities and Industries was read.

SATURDAY EXCURSION

On Saturday the members proceeded by a special trolley car to Akron, Ohio, where the works of the Goodrich Rubber Company were visited. The manufacture of automobile tires was first shown, including both cloth and the silvertown cord tires. The manufacture of waterproof clothing, conveyor belts and hood rubber articles was shown. Especial interest was taken in the very large jars for submarine batteries.

A complimentary luncheon was then served by the Goodrich Company at the Country Club. On return by trolley the meeting adjourned. The attendance, which was the largest in the history of the Institute, was unusually great in the Saturday excursion.

A fine program for the ladies was also carried through very successfully. It included an automobile trip to Lorain and Elyria, with complimentary supper at the Country Club at Elyria, also an automobile trip through the beautiful Cleveland park system and a theater party.

Program of the Fall Meeting of American Electrochemical Society

The fall meeting of the American Electrochemical Society will be held in New York City on Sept. 28, 29 and 30, 1916, that is, on Thursday, Friday and Saturday of the week of the Second National Exposition of Chemical Industries. The outline of the program is as follows:

Wednesday, Sept. 27, evening: General Reception, with registration, at the Chemical Exposition, Grand Central Palace.

Thursday, Sept. 28, forenoon: Reading and Discussion of Papers. General subject: "Made in America." Luncheon.

Afternoon: Visiting the Exposition.

Evening: *Complimentary Smoker.* An invitation will be extended to the members of the American Chemical Society and other visiting chemists and engineers.

Friday, Sept. 29, forenoon: Reading and Discussion of Papers.

Luncheon.

Afternoon: Visiting the Exposition.

Evening: *Subscription Dinner-Dance.*

Saturday, Sept. 30, forenoon: Reading and Discussion of Papers; possibly an excursion.

Luncheon.

Afternoon: Visiting the Exposition.

Mr. F. A. J. FitzGerald is president and Dr. Joseph W. Richards, Lehigh University, South Bethlehem, Pa., is secretary of the American Electrochemical Society.

The arrangements for the New York meeting are in the hands of the New York Section of which Dr. Colin G. Fink is chairman and Mr. J. Malcolm Muir, 239 West Thirty-ninth Street, New York, is secretary.

The Western Metallurgical Field New Mill of the Federal Lead Company

The Federal Lead Co. is one of the largest operators in the lead district of southeast Missouri. In addition to the 5000-ton mill which it is already operating it now has under construction a new 2500-ton mill which will be in commission this fall. Preparations for this plant were begun on Aug. 4, 1915, and from present indications it will be in operation within a year of that date, which will be a creditable performance considering that virgin land had to be cleared, wagon roads and railroads built, temporary structures erected for the accommodation of workmen, and an entirely new community established.

The site is on a hillside, at the bottom of which is the shaft and coarse-crushing department. From the shaft the ore will be conveyed by belt to the gyratories and thence to Symons disc crushers. The product of the latter will discharge onto an inclined belt conveyor leading to the mill bins, where it will be distributed by cross-conveyor.

The foundation and substructure of the mill building, including ore bins and jig and table floors, are of reinforced concrete, and the superstructure is of steel, giving a plant that will be light, clean and conveniently arranged.

Profiting by past experience at the old mill and by the general changes that have taken place in concentration throughout the district, the company will have an extremely simple flow-sheet for the new mill. The crushed ore will be separated into sizes suitable for jigging, tabling and flotation, and will be treated on six Hancock jigs, forty tables and a flotation plant consisting of Door thickeners, Janney agitation machines and air cells.

A Problem in Lead-Zinc Separation

A troublesome product made in varying quantity at the lead concentrating mills of southeast Missouri is a middling of zinc, lead and iron sulphides. The material makes its first appearance in the jigs, but is reground and retreated until finally it is discarded from the concentrating tables. At some of the mills it is separated and stored, awaiting future disposal; at others it is reground and redressed to yield a low-grade lead concentrate which is shipped to smelters. Mechanical methods have failed to make a satisfactory separation of the constituents of this material, and considerable experimenting has been done to determine an economical method of treatment. Roasting and magnetic separation do not give satisfactory results, nor does any system of grinding and concentration, either wet or dry. The minerals are so intimately associated that some hydrometallurgical scheme seems necessary for their separation and recovery, and further work is being done along this line in the hope of solving the problem. Possibly roasting and leaching would effect a separation of the two valuable metals, leaving lead in the residue and giving a solution of zinc for electrolysis.

Flotation of Zinc Tailings at Joplin

The first individual flotation plant to operate on a commercial scale in the Joplin zinc district is that of the Mining & Flotation Company of Denver, under the direction of S. P. Warren who designed and

erected the mill. The material treated is taken from an old tailing dump on a lease of the Granby company at Chitwood, and contains about one per cent of blende and a small quantity of galena. It is brought to the mill by teams and scrapers, dumped over a grizzly and elevated with water to a trommel screen of 1-mm. mesh. The oversize is discarded. The undersize is deslimed by an inclined screw conveyor giving a coarse sand discharge and slime overflow. The sand is classified and treated on four tables, while the slime is thickened in a V-box and pumped to the 6-cell flotation machine. An oil mixture, containing mainly pine oil, is added at the first cell and the mixture flows successively through the six cells of the machine. The tailing is discarded, but the frothy concentrate is dressed on a concentrating table in order to raise the grade in zinc. The table tailing and middling is returned to the flotation machine. About fifty per cent of the total mill production is made by flotation and the balance on the four tables. The mill is treating 80 tons of material in 10 hours and producing 1600 pounds of 50 per cent zinc concentrate.

The Tungsten Situation in Colorado

Following the sharp reaction in tungsten prices which demoralized the market several weeks ago, there has been a gradual recovery, and the large producers are continuing operations as usual. The Primos Mining & Milling Co. has remodeled the crushing department of its large plant at Primos, abandoning the stamps which have been criticized on account of their production of slime. The same company is continuing the construction of a new mill at Crescent in Boulder county, and the Rare Metals Extraction Co., composed of Cripple Creek operators, also is building a new custom mill at Rollinsville, which is expected to be in operation by July 1.

In an effort to make themselves independent of an uncertain market for tungsten concentrates, some operators are investigating the possibilities of making ferro-tungsten. Thus far the proposal seems feasible, for power is at hand from the hydroelectric plant of the Colorado Power Co., and specially high-grade concentrates could be produced without difficulty. Current specifications for ferro-tungsten, which the local producers would have to meet, demand a specially low content in carbon and phosphorus. Other deleterious substances are sulphur and manganese. The following limits are imposed: Tungsten, not less than 70 per cent; carbon, not more than 0.6 per cent; phosphorus and sulphur, each not more than 0.05 per cent; manganese, not more than 1.0 per cent. In case the concentrates produced are not rich enough to yield a ferro-tungsten containing 70 per cent tungsten, it may be necessary to produce some tungstic acid to add to the charge. In addition to the proposal to make ferro-tungsten, there is also a possibility that tungsten metal in powdered form may be made from tungstic acid. The latter article is now produced in the district. The recent flurry in the market has impressed on operators the necessity of greater independence, and it is likely that they will not stop at making concentrates but will extend their operations to include a more finished product.

Resolutions Favoring Nitrogen-Fixation Plant

At a recent meeting of engineering and scientific societies held in Denver, attention was directed to the importance of constructing in this country suitable manufacturing plants for the fixation of atmospheric nitrogen. A committee was appointed consisting of representatives of the national engineering

institutes, to draft resolutions for endorsement by the Colorado sections of those bodies, for presentation to Congress. These resolutions set forth the economic and industrial importance of nitrogen and its compounds, and urge upon Congress the necessity of action that will aid in the development of nitrogen-fixation plants, both by private enterprise and by the federal government. Congress is asked to appropriate \$100,000,000 for the purpose. The resolutions have been submitted to the members of the Colorado bodies, and have been endorsed by several of them.

Company Reports

The 1915 annual reports of the five important porphyry copper producers, **Utah, Ray Consolidated, Nevada Consolidated, Chino and Miami**, contain unusually interesting and important information, showing marked increase in efficiency of operation and decrease in cost of production, despite the fact that operations were not conducted at full capacity during the first part of the year. The following tabulation contains essential data on milling.

CONDENSED DATA FROM ANNUAL REPORTS, 1915, OF PORPHYRY COPPER COMPANIES

	Utah Copper	Ray Cons.	Nevada Cons.	Chino	Miami
Ore reserves, tons	390,000,000	71,911,475	50,525,289	90,000,000	35,140,000
Ore reserves, % Cu	1.447	2.235	1.652	1.75	1.82
Ore milled, tons	8,494,360	2,848,969	3,061,520	2,379,800	1,348,122
Ore milled, % Cu	1.434	1.673	1.540	2.155	2.17
Ratio of concentration			7.18	15.02	
Concentrates produced, % Cu	19.17	19.29	7.77	21.55	41.91
Percentage recovery	64.13	64.11	70.12	68.59	75.17
Copper produced, lb.	156,207,376	62,540,196	62,726,651	68,293,893	41,822,059
Cost of milling, ¢ per ton	34.02	50.86		54.19	57.94
Cost of copper, ¢ per lb.	(7.566)	(9.476)	(8.676)	(7.126)	
	16.61c	(9.423c)	(8.23c)	(6.75c)	6.05d

^aIncludes 1,425,682 lb. ore shipped direct to smelter.

^bAverage net cost after making allowances for smelter deductions and crediting gold and silver values, etc.

^cAverage net cost after crediting miscellaneous income.

^dCost of refined copper in concentrates on cars at Miami.

In addition to the foregoing, the following items pertaining to the different companies may be given. The **Utah Copper Company** milled 1,252,295 tons more ore than in 1914, and for the last six months of 1915 the daily capacity was 26,537 tons, or 33 per cent above normal capacity. Investigative work was done looking toward the treatment of the oxidized capping which has been and is being removed from the sulphide ore bodies. A leaching plant has been authorized, with an initial capacity of from 2000 to 3000 tons per day, and arrangements have been made to participate equally with the Garfield Smelting Co. in financing the construction and operation of a sulphuric acid plant near the latter company's smelting works.

At the smelting plant of **Nevada Consolidated**, improvements were made in the roasting department, whereby the tonnage of concentrates calcined per furnace day averaged 86 tons, as against 76 in 1914. In the reverberatory department a considerable reduction in cost per ton of material treated was obtained. The cost of converting was the lowest ever obtained since the converters were blown in, being \$9.76 per ton of blister copper. The grade of matte was considerably lower than during any other year, being 27.2 per cent copper.

Increase in tonnage treated was obtained by the **Chino** company during the last eight months of 1915, when an average of 1573 tons per section-per day was treated.

The **Miami** company showed a marked increase in percentage recovery, from 69.93 per cent in 1914 to 75.17 per cent in 1915. The grade of concentrate also

was increased from 39.31 per cent copper to 41.91 per cent. An experimental plant for the treatment of oxidized copper ore may be started in the near future. Laboratory results on this work have been encouraging.

The Iron and Steel Market

The significant fact in the dullness of the steel market is that it has developed no weakness. On the contrary, the situation is clearly a strong one, and this is a fact that could not be well brought out in an active and steady market. There is absolutely no disposition on the part of mills to cut base prices of finished steel for forward deliveries. It is true that premiums for prompt and early deliveries have continued to dwindle, until now they are almost negligible, except in the case of plates.

Strictly new buying of steel products is very light, and there is also a decrease in the volume of specifications filed against current contracts. There will be a further decrease in the total volume after July 1, as a number of relatively low-priced contracts expire by limitation with the June quarter.

Export demand continues heavy. Since the early part of April the export demand has continuously been heavier than at any previous time since the war started, but there is this change, that a month or two ago by far the major part of the export demand came from the allied belligerents, whereas of late the demand from neutral countries has been much more pronounced. The demand from neutrals is in part a reflection of lower ocean freights and in part a reflection of the complete exhaustion of their steel. The opening of the war found the countries that are far removed from sources of supply with large stocks of steel, while the actual consumption was greatly reduced. In the early months of the war there were many who predicted that the real demands of neutral countries would not find expression in actual buying until more than a year had elapsed. In some quarters the opinion is expressed that the volume, in tonnage, of export business is greater than that of domestic.

The dull domestic market is generally expected to continue through August. Then there should be a resolution of forces. While the large mills are filled with business quite comfortably through the year, and to an extent into the new year, many of the smaller mills are filled only for two or three months. A continued dull market would necessitate their seeking additional business within two or three months, while on the other hand the development of an amount of fresh demand, quite moderate in proportion to the total capacity of the country, would probably find insufficient mill capacity open to meet it.

In prognostications for the future account must be taken of the fact that even at this time a considerable proportion of the steel being shipped is invoiced at relatively low prices, being in fulfillment of old orders. The present rate of consumption is not necessarily an index to the rate that would obtain were all consumers, down to the ultimate consumer, forced to pay the present mill prices for finished steel.

Pig Iron

An unprecedented situation has developed in the Southern iron market. When the market was low last year a great deal of iron was bought speculatively, most of it in warrants. The typical speculative holder of pig iron warrants refuses to sell when the market is advancing, i.e., when consumers are buying pig iron, and insists upon selling when the market has stopped

advancing, i.e., when consumers will not buy. As a rule he thinks the pig iron market should absorb pig iron as the stock market absorbs stocks, but sometimes it will not do so. Ordinarily pig iron warrants can be disposed of, even in a dull market, at a slight concession from the furnace price, but in the past fortnight, as Southern iron offered by furnaces was declining slightly, to \$14.50, Birmingham, warrants were sold at \$13.50, and even in a few instances at \$13. The effect of these transactions has been to block the regular business in Southern iron and to affect sentimentally the position of buyers of Northern iron. We quote: No. 2 foundry iron, delivered Philadelphia, \$19.75 to \$20.25; f. o. b. furnace, Buffalo, \$18.50 to \$19; delivered Cleveland, \$19.30 to \$19.80; f. o. b. furnace, Chicago, \$19; f. o. b. Birmingham, \$14.50 to \$15 for furnace iron, warrant iron unquotable; f. o. b. valley furnaces, 95c higher delivered Pittsburgh; Bessemer, \$21; basic, \$18.25; foundry, \$18.25 to \$18.50; malleable, \$18.25; forge, \$18 to \$18.25.

Steel

The billet and sheet bar market is a trifle easier. Soft steel to be made to specifications as to size and analysis is not over \$42 for Bessemer and \$45 for open-hearth. Odd lots arising in the course of steel mill operations usually bring \$2 to \$3 a ton less, while nondescript material, chiefly second discards and rejections arising in the filling of shell steel orders, go at widely varying prices, according to whether they suit the requirements of a purchaser or are acceptable only because they are cheap.

Non-Ferrous Metal Market

Monday, June 26.—Dullness has characterized the market for most of the metals during the last two weeks, and a general decline has taken place. This is especially true of copper, lead, spelter and antimony. The consumption of tin is very good, and although it has been declining, it shows signs of reacting and developing strength again.

Copper.—The copper market has been dull and weak and spot electrolytic has dropped about 1 cent per pound to 26.75 cents. Producers are not cutting their prices as they have no substantial amount of copper for sale for delivery earlier than the last of the year. The labor situation is largely responsible for the unsettled condition of the industry in a good many quarters.

Second hands are now quoting electrolytic at 26¼ cents for deliveries in July, August and September, and 26 cents for the last quarter. A considerable export inquiry is reported. Exports have been good this month and up to June 22 were 23,925 tons of 2240 lb.

Tin.—Straits tin declined steadily from 44.25 cents on June 12 to 39.25 cents on June 22, but on June 23, showed signs of an upward turn and advanced to 40.25. The consumption of tin is known to be very good, but the amount of spot tin offered for sale has been quite large and consumers would not buy extensively on a declining market. The foreign market has been weak up until June 23, and the weakness was reflected in our market.

Shipments of tin into this country up to June 23 were 4650 tons.

Lead.—The Trust price still remains at 7.00 cents with independents quoting 6.85 to 6.95. For the most part the market has been dull, although large export sales have been reported as recently made.

Spelter.—Spelter has been consistently dull and weak, and spot has declined to 12.00 cents, a drop of almost

2 cents in the last two weeks. The demand for futures which are quoted at 11 cents for September delivery is better than the demand for spot. Earlier deliveries range from 11 to 12 cents.

Other Metals.—Antimony continues dull and is now quoted at 18.50 with very little business done. Aluminum is an exception in the general market and is very strong at 64 cents for Virgin metal. Platinum is quoted at \$75 per oz. with quicksilver at \$76 per flask. Silver is quoted at 65½¢.

Coming Meetings and Events

American Electro-Platers' Society, Cleveland, July 6-8.

National Fertilizer Association, Hot Springs, Va., July 10 to 14.

American Institute of Metals and American Foundrymen's Association, Foundrymen's Convention, Cleveland, Sept. 11-16.

American Institute of Mining Engineers, Arizona, Sept. 18-23.

Mining and Metallurgical Society of America, New York Section, New York, Sept. 21.

Second National Exposition of Chemical Industries, New York, Sept. 25-30.

American Chemical Society, New York, Sept. 25-30.

American Electrochemical Society, New York, Sept. 28-30.

Court Orders Dissolution of Corn Products Refining Company

In the case of the Government versus Corn Products Refining Company, a decision has been rendered by the U. S. District Court.

The quite lengthy decree which had been written by Federal Judge Learned Hand sustains the Government's contention that the Corn Products Refining Co. constitutes a monopoly in restraint of trade under the terms of the Sherman law. The corporation is to be dissolved and a plan for dissolution filed with the Federal Trade Commission within 120 days.

This commission, acting as master in chancery, is to report in due time a plan for disuniting to the Federal Court.

It is expected that an appeal will be taken from the decision.

Water Power Development

Resolution of Joint Conference Committee of National Engineering Societies

The Joint Conference Committee of National Engineering Societies has addressed the following letter to the President, dated June 28, 1916:

"To the President, Washington, D. C.,

"I take pleasure in transmitting to you a copy of a resolution adopted by the Joint Conference Committee of National Engineering Societies at its meeting held on June 15, 1916: 'The Joint Conference Committee of National Engineering Societies believes that the development of the country's undeveloped water power will increase national prosperity; that private enterprise should be encouraged and stimulated to expedite such development; that unnecessary legal burdens should be removed and existing doubts as to the safety of investment eliminated. It commends to the support of engineers all efforts made to secure the fullest publicity as to the underlying facts regarding this subject.'

"The Societies by which this Committee was constituted are: The American Society of Civil Engineers, The American Institute of Mining Engineers, The Amer-

ican Society of Mechanical Engineers, and The American Institute of Electrical Engineers—therefore, it speaks in the name of about 30,000 engineers.

"Yours respectfully,

"CHARLES WARREN HUNT,
"Secretary."

The Joint Conference Committee consists of Calvert Townley, chairman; Chas. Warren Hunt, secretary, and Robert Ridgeway, S. L. F. Deyo, Arthur M. Greene, Jr., D. S. Jacobus, Charles Whiting Baker, J. Parke Channing, Benjamin B. Lawrence, Bradley Stoughton, and William McClellan.

Atlantic City Meeting of American Society of Testing Materials

The nineteenth annual meeting of the American Society of Testing Materials was opened at the Hotel Traymore, Atlantic City, N. J., on Tuesday, June 27. The meetings have been held at Atlantic City for the last ten years.

At the beginning of the Tuesday session the attendance was 250, but at the end of the first day the registration had reached 325. President MANSFIELD MERRIMAN called the meeting to order. The annual report of the executive committee was read by Secretary Edgar Marburg. The chief features of this report were data showing a greater increase in membership in the Society during the last twelve months than in any preceding year (the Society now having 2071 members), an account of the continued good work of the standing committees which form such an important feature of the Society, a discussion of the eligibility of candidates for the nominating committee, and an account of the provisions formally agreed to between the U. S. Department of Commerce and the Society. A resolution was passed that any member who had served the previous year could not serve again on the nominating committee until one year had elapsed, except the three past presidents who automatically become members. The report also included a discussion of the most important matters brought up at meetings of the executive committee during the last two years and a proposal to publish the Year-Book of Standards biennially, instead of once a year. This was voted upon by the Society and passed.

Several reports of standing committees were then read. That on Standing Committees, E-5, was read by Edgar Marburg, chairman; that on Wrought Iron, A-2, by S. V. Hummings, chairman; that on Papers and Publications, E-6, by Edgar Marburg, chairman. The committee on Standing Committees recommended a greater simplicity in the designation of technical committees and standards and also devoted considerable attention to amendments to the Regulations Governing Standing Committees.

Following the committee reports the announcement of the annual election of officers was made. The new officers are as follows:

President, A. A. STEVENSON; vice-president, S. S. VOORHEES. Members of Executive Committee: W. H. BASSETT, JOHN BRUNNER, G. W. THOMPSON and F. E. TURNEAURE.

The Society's new president, who is vice-president of the Standard Steel Works Co. of Philadelphia, Pa., in accepting the chair said that he was the first producer to be elected to the office, and he thought that it was indicative of more cordial relations between the producer and the consumer. He said that it should be his endeavor, however, to conduct the office in a strictly im-

partial manner, and to sustain and forward the work and ideals of the Society.

The afternoon meeting was presided over by General W. H. BIXBY, U. S. A., retired, and was given over entirely to committee reports, on miscellaneous materials. The report of Committee D-3, on Methods of Sampling and Analysis of Coal was read by S. W. Parr, chairman; the report on Committee D-5, on Coal by G. S. Pope, chairman; the report of the Committee on Shipping Containers by B. W. Dunn, chairman; the report of Committee D-11, on Rubber Products, by E. A. Barrier, chairman; the report of Committee D-13, on Textile Materials, by W. D. Hartshorne, chairman. All of these committees had been active and made important recommendations in their reports.

At the Tuesday evening meeting at which the new president A. A. Stevenson was in the chair, an address was presented by retiring President M. Merriman on the work of the committees of the Society. He emphasized that every member of the Society should be gratified at the results of the work of its technical committees. They have thrown new light on many problems of mechanics and strength of materials. Standards have been adopted which have promoted harmony between producer and consumer and which will be of great benefit to the industrial interests of the country. The Society now has thirty-seven committees.

The presentation of papers followed. An account of the same and of the proceedings of the following days is reserved for our next issue.

Industrial Preparedness the Subject of a Commencement Address

At the commencement exercises of the University of Pittsburgh Dr. Leo H. Baekeland delivered the commencement address on industrial preparedness, showing how the preparedness idea has brought forward a set of problems of national efficiency which are interconnected and in which chemistry plays a very important part. Almost every one of these problems is just as important in time of peace as in war. Preparedness against aggression is the best way of insuring the peaceful destiny of the country.

The honorary degree of Doctor of Chemistry was conferred on Dr. Leo H. Baekeland and Prof. J. O. Stieglitz.

Pay for National Guardsmen

In common with a large number of industrial concerns the McGraw Publishing Company, Inc., publisher of "Metallurgical and Chemical Engineering," as well as of "Engineering Record," "Electrical World," "Electric Railway Journal," and "Electrical Merchandising," is continuing payment of their regular salaries to those of its employees who are now members of the National Guard or Naval Reserve and who have been called into the service of the United States. As far as possible the employees will not only be kept on the payroll but their places will be kept open for them until the need of their military service will have ceased.

The good wishes of the whole organization go with them to the front. To those who have to stay at home it is left to continue to preach that the greatest preparedness-problem for this nation still remains to be solved—the problem of efficient nation-wide industrial preparedness.

Coke-Oven Accidents is the title of Technical Paper 151 of the Bureau of Mines, the author being Albert H. Fay. The detailed report shows a gratifying decrease in the number of fatalities and injuries in 1915.

Sources of Metal Loss in Copper Refining

BY LAWRENCE ADDICKS

It is only recently that the general question of metal losses in metallurgical practice has begun to receive anything like the attention it deserves. In any scheme of metallurgical treatment it is always easy to recover say 50 per cent of the value in an ore by some simple direct process. Then improvements are made which will bring the total recovery up to perhaps 65 per cent, but this additional 15 per cent has cost more per unit than the first 50 units. The process gradually develops until the additional complexity brings the operating cost up to a point where further recovery would cost more than the value of the additional metal recovered. It is also soon found that a 65 per cent process can profitably treat a leaner ore, and this adds another variable to the most economical efficiency equation.

Nor is the study of the various sources of metal loss a simple analysis of slag and stack losses although these are among the largest and most obvious sources. While this article deals with copper refining, or the separation of blister copper into fine copper, gold and silver, the method of examination will apply equally well to any other metallurgical process.

Fig. 1 gives a flow sheet of the process under con-

E. Stack Losses:

- a. Anode furnace stacks.
- b. Refining furnace stacks.
- c. Silver refinery stacks.
- d. Cupola stack.

F. Process Losses:

- a. Silver and gold in outgoing copper.
- b. Silver in outgoing gold.
- c. Gold in outgoing silver.
- d. Minor losses.
- e. Process margins.

G. Handling Losses:

- a. Wind losses.
- b. Theft.
- c. Solution losses.
- d. Soil losses.
- e. Slimes losses.

A. Weighing

Scales are about the most precise pieces of physical apparatus we have. In the laboratory when we get a sensitiveness of 0.01 mg. with a capacity of 1 gram, we are working to 0.001 per cent and even lesser ratios are obtainable. In large-capacity scales the best precision obtainable is about 0.01 per cent; that is, if we want to be sure of the nearest pound we must not use drafts exceeding 10,000 lb. Using a 200,000-lb. railroad scale which to-day can be made distinctly responsive to a 20-lb. change in load gives the same precision, but does not equally satisfy a customer who places great stress on individual pounds.

It is, therefore, customary to weigh outgoing copper in 5-ton drafts under such conditions that the refineries have been able to stand upon their weights as final, provided the consignee agrees with the count of pieces. In order to accomplish this, two platform scales are placed in tandem, separate weighers taking readings and comparing figures before passing a lot. These scales are either of the overhung type where the knife edges are overhead and always in sight, or baby railroad scales. The latter are to be preferred as they are free from the obstructions above the floor line

and it is possible to arrange the live platform so that an oncoming car divides the shock between two pairs of knife edges, greatly saving wear.

The standard of weight is furnished by the certification of the U. S. Bureau of Standards of a 50-lb. brass weight as a "Class B or Working Standard." Against this are checked a sufficient number of 50-lb. cast iron weights, adjustable by lead shot, to make up a full-scale load.

These weights are not suitable for every-day use as they afford a great surface for the condensation of moisture, collection of dirt, etc., so a test car loaded with very heavy cast iron weights is checked against them every two or three weeks and this test car is used for daily checks on the merchant scales. In this way it is quite practicable to maintain the desired precision of

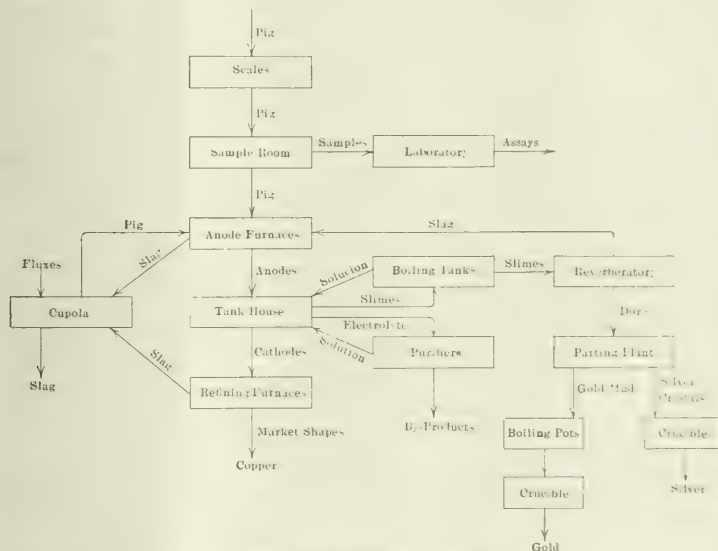


FIG. 1—DIAGRAM OF PROCESS

sideration, reduced to its simplest terms. The sources of loss to be considered may be classified as follows:

A. Weighing:

- a. Incoming blister copper.
- b. Outgoing copper.
- c. Outgoing silver and gold.

B. Sampling:

- a. Moisture.
- b. Errors in method.
- c. Salting.

C. Assaying

- a. Assay methods.
- b. Splitting limits.
- c. Assay errors.

D. Slags:

- a. Cupola slag.

1 lb. in 10,000. As identical methods are used for weighing incoming blister and outgoing wirebars there is but small chance of tracing any copper losses to scales in a modern plant.

In weighing the silver and gold the situation is somewhat different. The incoming silver and gold are weighed as blister copper as outlined above, while the outgoing shipments are weighed as bullion. As the gold is always shipped to a U. S. Assay Office whose weights are final, we again come to government standards and have automatically a weekly check against the refinery bullion balance. In one of the large refineries a year's returns showed a difference of but 0.0015 per cent. As a bullion balance is furnished with a set of weights instead of a sliding poise, it is comparatively easy to make mistakes in reading. To lessen this danger it is well to provide a direct-reading spring balance upon which a check to the nearest ounce can rapidly be made.

One of the most fruitful sources of error in weighing lies in the inaccurate taring of cars. Slight differences are bound to occur daily as the oil works out of the bearings but this is not serious. Wear and tear gradually lowers the weight of a car and it should be tared at least every ten days, the weight and date being painted on each side of the car and the rule adopted not to use any out-of-date cars. Similarly a car sent to the shop for repairs should have the weight painted out.

B. Sampling

a. Moisture. It is generally assumed that copper carries no moisture. This question was first raised a good many years ago when some blister copper from Australia which had been more or less immersed in bilge water in transit was found to carry about 0.5 per cent of moisture. Pig copper is quite porous and a quart of water poured on the face of a pig will vanish as if absorbed by blotting paper. Some of the Western smelters are quenching their converter bars in boshes which brings this question up again. About all that can be done in such cases is to make careful tests in a drying oven on certain pigs and apply the correction found to the lots represented. It is evident that a very serious source of loss may pass unsuspected if this is not watched, as the refinery will be accounting for water as copper, silver and gold.

Then we have the question of weighing material that has been exposed to inclement weather. This should never be done, but sometimes it has to be done in order to save large delays, and it is then necessary to impose an arbitrary allowance by agreement. The weighing of hot wirebars does not seem to cause any appreciable error, the rising air currents being negligible. Weighing in the wind is more serious and scales should always be well protected.

b. Errors in Sampling Method. The silver and gold contents in a ton of blister copper may be worth anywhere from \$10 to \$500, although, fortunately for the refiner's peace of mind, there are very few very rich bullions. One hundred dollars per ton would be an ordinary figure, however. It can readily be seen that a small error in determining the true metal contents of blister copper would have an alarming effect upon the refiner's profits. A great deal of experimental work has therefore been done in developing standard sampling methods.

Blister copper usually runs 98 per cent to 99 per cent copper, the bessemerizing of matte having reduced the impurities to small values. The molten blister is poured into open molds and whether or not the copper is afterwards quenched in water it is always allowed to set before being removed from the mold. The pig therefore cools most rapidly on the sides and bottom, the heat be-

ing absorbed by the metal mold, and the last spot to cool is the upper central portion. The silver and gold and other impurities form a complicated series of solid solutions and eutectics with the copper, the richest portion in precious-metal values being the last to solidify.

It is evident that any system of sampling must bear this in mind. Theoretically this would require that when a sampling templet is laid out with a series of holes for drilling, these should be arranged to straddle and not pierce the center line of the pig, as no compensating holes can be drilled in the absolute edge of the piece. Practically this does not seem of great importance as experiments have shown that the richest zone often lies in a ring around the center rather than in the actual center, but it is still wiser to follow the proper practice as different combinations of impurities produce quite different results.

The old-style pig, shaped more or less like a loaf of bread, is now no longer in use except in South America where purchases of bullion are generally made by lot at auction rather than by contract. These old pigs were 6 in. thick and the segregation defied accurate sampling at a reasonable cost. The refineries have succeeded in introducing a bar about 18 by 27 in., $2\frac{1}{2}$ or 3 in. thick, weighing about 300 lb., with just sufficient draft to facilitate removal from the mold and preferably unquenched. This readily yields an accurate sample, stacks well and is heavy enough to be an economical unit in handling.

The Japanese still make a very small pig weighing some 50 lb. These cause heavy sampling and handling costs and are therefore undesirable. Once in a long while copper comes from some out-of-the-way corner of the world which has been cast in pots and these cases call for considerable knowledge and ingenuity on the part of those in charge of the sampling.

A number of other precautions must be taken to secure an accurate sample of pig copper. There must be a sufficient number of holes in the templet—that is, one hole must not represent too large an area, otherwise experience has shown that the sample will be too high. In fact, careless sampling will generally give results on the high side. On the standard pig a quarter templet with forty-eight $\frac{1}{2}$ -in. holes is generally used; this gives an area of about $2\frac{1}{2}$ sq. in. per hole. Each hole is in the center of a rectangle, arranged so that forty-eight such rectangles would just cover one-quarter of the area of a pig. The hole is drilled completely through the pig, each successive pig sample being marked at the next hole in rotation on the templet. In these days of large converter pours it is seldom necessary to drill every pig, one in three, four or even five being sufficient.

It must be realized that there is always more or less dirt on the surface of a pig and also that the set side has an oxide film which may run quite different in values from the body of the metal. It has been proved that decidedly different samples are obtained from a lot depending upon whether the pigs were drilled face up or face down, and further that while for a given brand of pig these differences are generally consistently in one direction, some brands would be the reverse of others. This dilemma has been met by using the so-called top and bottom method. Originally every other pig was turned bottom up, but it was found equally satisfactory to drill every other lot bottom up. No water or other lubricant should be used on the drill as this will tend to oxidize the hot drillings.

A splash sample taken at the smelter by collecting a fraction of the converter pour as shot in water will always show high metal values as against the refinery as such a sample is automatically freed of dirt and slag. For a long time the smelters felt that their splash samples were correct and that the refineries' samples low,

but it has been shown that a properly taken sample at the converter, using no water, can be made to check drill samples on the pig.

Enough has been said to show that sampling methods are a matter of the highest importance in any study of the sources of metal loss, as the refiner has to pay on the values shown by the sample whether or not they exist in the pig.

c. *Salting.* The contamination of a sample during preparation may cause serious errors and consequent apparent metal losses. Nowadays this is seldom done deliberately, although the large laboratories generally have one or two interesting stock tales of this character. It may easily be done unconsciously, however, if silver-refinery slags, doré samples, etc., are handled in the same department as incoming pig copper. The only sure way is to absolutely separate such different classes of work.

C. Assaying

a. *Assay Methods.* In the early days an assay method was supposed to represent the process to be used and the assay value was admittedly lower than the true contents by an amount approximately equal to the expected loss in treatment. In other words, the assay value was the recoverable value. To-day the tendency is to adopt methods which will give the highest result compatible with reliability but which still do not in all cases give full contents. The electrolytic assay for copper does give full value; in fact the chief danger in the handling of this method is that some impurities may be deposited on the cathode and weighed up as copper, to the disadvantage of the refiner.

The so-called uncorrected combination assay for silver in which the bullion is dissolved in nitric acid, the silver precipitated as chloride which in turn is scorified to gather the silver (and gold) into a lead button, the button being cupelled and the resultant lead weighed as silver plus gold, does not give full value of silver by from 2 to 3 per cent. The loss is due to values in scorifier slags, to cupel absorption and to volatilization. The main argument for this method is that when conscientiously run it will duplicate results very closely while there is at present no really satisfactory method of determining the absolute silver contents of foul bullion.

Skill is required in maintaining the proper temperature when cupeling; it must be hot enough to make the button "blick" at the finish, or it is not pure and other elements are weighed as silver; on the other hand it must be cool enough to show "feather" litharge around the edge of the cupel when finished, or the volatilization loss will be excessive.

Mismanagement in the laboratory may easily affect the apparent or financial metal losses. In some cases the "corrected" assay is used, where the losses in scorifier slags and cupels are determined and added, bringing the recovery up to about 99 per cent. Nothing is gained in accuracy and when once the particular bullion is known, the amounts of these losses are very constant and can just as well be allowed for arbitrarily in the refining terms, avoiding the expense and delay of determining daily corrections.

There is no practical way of ascertaining the volatilization loss except by running "proofs" made up with known quantities of silver. With high-grade doré and similar pure material this is satisfactory, but when various impurities are present, they affect the volatilization and a true proof would be a very complicated affair.

In the case of gold the fire assay, where the bullion is scorified direct to a lead button, is used as it gives a higher value than the gold parted from the silver in the combination assay, due probably to filter losses and the oxidation of some gold when dissolving the bullion

in nitric acid in the latter method. This gives a return of about 99.6 per cent in the uncorrected assay. The corrected gold assay is very close to full value.

b. *Splitting Limits.* Were assays absolutely accurate and all laboratories equally reliable, the question of splitting limits would not enter into a discussion of metal losses. As such is not the case it is necessary to agree upon some reasonably allowable difference between buyer and seller within which assays shall be averaged or "split" and beyond which an umpire assayer shall be called upon.

In order to guard against either dishonesty or carelessness several simple precautions should be taken. In the first place assays should be exchanged simultaneously by mail; then all "reassays" to avoid umpires should be forbidden; finally, splitting limits should be made as close as possible. Sometimes the splitting limits are made very close, such as 0.1 per cent for copper, for example, and then only such umpires undertaken as may be necessary to bring the average results for ten consecutive lots within splitting distance.

The umpire should be considered simply as a substitute for one assayer, not as a source of authority. When two assays fall too far apart, the assumption is that one is incorrect and the umpire will determine which one it is. His result should therefore be averaged with the nearest original result unless it is above the higher or below the lower by more than the splitting limit, in which case the sample is pronounced uneven and the two original assays averaged for settlement.

In many cases where wild umpires are reported the trouble with the sample can be rectified by screening out the fines in the sample and then making up a portion for assay with just the proper proportion of fines, the more impure parts of the alloy having been brittle and pulverized under the drill.

It is also well to have two or three competent umpire chemists agreed upon, assigning umpires, as they become necessary, in rotation. This tends to check any inaccuracies in the umpire laboratory.

c. *Assay Errors.*—Assays are subject to three sources of error: (1) those of method; (2) those of procedure; (3) those of calculation, or clerical errors. The first has already been dealt with and may be classed as a voluntary error; the second may be due to carelessness, inaccurate apparatus, such as scale weights or burettes, or impure reagents; the third is more serious than might be imagined and constant vigilance is necessary. Perhaps the most common clerical error is that of reporting double or half the proper value in silver and gold determinations, due to failure to note the fraction of an assay ton taken for assay.

D. Slags

We have now to pass from the apparent losses due to inaccurate accounting for values in the incoming bullion, to the actual metallurgical losses, and the first of these is the loss in the cupola slag. The anode and refining furnace operations produce a certain amount of slag due to the reaction between the metallic oxides formed during scorification in the furnace and silica and other oxides present in the furnace walls and hearth, or introduced as coal ashes blown over from the fire box, or as clay used in luting up the doors, fettling, etc.

In the old days of small furnaces constructed entirely of siliceous material, from 3 to 4 per cent of the weight of the charge was made in slag. In the large modern furnaces constructed partly or wholly of basic or neutral material and with much better fuel economy, the slag made is below 1 per cent.

Theoretically the slag should be a very small item. After a charge is melted air is blown in sufficient to oxidize part of the copper. This cuprous oxide in turn

displaces the impurities by oxidizing them and sending them into the slag. The cuprous oxide is soluble to a certain extent in the molten copper and were no acids present it would be theoretically possible to skim off simply these impurities with a little mechanically entangled copper. The actual slags made run about 45 per cent copper and must be treated in a blast furnace with fluxes such as iron oxide and limestone to make black copper unless a smelting plant is connected with the refinery.

If some sulphur is introduced into this charge a low-grade product running about 94 per cent copper may be made with a slag running below 1 per cent in copper, but this gives a high operating cost in the anode furnace.

If a high-grade black copper is made it is very difficult to get a slag below 2 per cent in copper. Taking a final cupola slag of 36 per cent silica and neglecting the small quantity of silica introduced by the basic fluxes, this means that every ton of silica which is allowed to find its way into the refining furnace slags carries away from 56 to 112 lb. of copper in cupola slag aside from the stack loss in this operation. It is evident therefore that this great source of loss is worthy of the most careful study, to the end that the least possible amount of slag be made at the reverberatories.

E. Stack Losses

a. Anode furnace stacks.

b. Refining furnace stacks.

Not a great deal is known about these losses. The recoveries in flue dust from waste-heat boilers installed in anode furnaces show some 0.07 per cent of the copper treated, rather more of the silver and less of the gold. On the other hand, bag-house tests on the gases escaping from a high direct stack have shown less than this amount. The composition of the bullion under treatment has doubtless much to do with these losses, as the recoveries on furnaces treating cathodes are much less, due partly to less working of the molten charges and partly to the absence of volatile impurities which always promote metal losses.

c. *Silver refinery stacks.*—The anode slimes consist of the insoluble impurities contained in the anode and run 30 per cent to 40 per cent in silver. The copper is mostly leached out as sulphate and the slimes are then melted and subjected to a series of oxidizing operations until a high-grade doré is obtained.

In general about 1 per cent of the silver treated and about 0.1 per cent of the gold is recovered by various means in the flue system and great progress has been made in the last ten years in this practice.

Until the Cottrell system of electrostatic precipitation was successfully applied to treating these gases, the opportunities for serious undetected losses were very great and even now there is no point in a metal loss investigation which needs more careful watching.

The great difficulty is that the actual losses made are clearly discernible only after several years, as the results from single yearly inventories are always more or less clouded by anode furnace bottom absorptions which vary from year to year, and the punishment comes so long after the crime that it is very easy to be lax to the immediate benefit of apparent operating costs. Molten silver should be handled like a volatile liquid.

d. *Cupola Stack.*—This loss should be relatively small, as the operations are on a small scale and the charge in reasonably good physical condition. A proper dust chamber should be installed, however.

F. Process Losses

a. *Silver and gold in outgoing copper.*—This loss is a perfectly definite one shown by daily assays. In gen-

eral the loss runs from 0.5 to 0.8 per cent of the silver and gold present in the anodes. In the case of low-grade anodes this is not serious, but when rich material is being treated this loss becomes quite an item. The loss is due to slimes adhering to the cathode and is affected by the current density, the volume of circulation of the electrolyte, and the degree of refining given in the anode furnace.

b. *Silver in outgoing gold.*—The Government does not pay for the silver in gold deposited unless the fineness is low enough to require refining. In the latter case the refining charges imposed greatly exceed the costs of refining before shipment. The net result is that any silver contents are not paid for and therefore constitute a metal loss. This loss should not exceed two or three parts per thousand.

c. *Gold in outgoing silver.*—Any gold in outgoing fine silver is, of course, a total loss. It should be possible to keep this loss down to 0.1 oz. per ton of silver.

d. *Minor losses.*—These comprise values lost in any by-products sold, such as nickel sulphate, selenium, platinum, etc., and the value of assay samples sent out without credit, etc. These sources of loss are relatively unimportant but should not be overlooked.

e. *Process margins.*—These are negative losses or gains due to receiving more metal than accounted for, or to shipping less, due to trade customs. In copper there is no assay margin, but there is a gain of about 0.07 per cent due to the fact that wirebar copper runs but about 99.93 per cent copper, while it is credited as 100 per cent against incoming copper received on actual contents.

In the case of silver the uncorrected combination assay allows the refiner about 2.5 per cent margin while on shipments of fine silver, although the assay used shows true contents, a fineness of 999 is considered a 100 per cent delivery. With gold there is a margin of about 0.4 per cent in the incoming bullion from the fire assay used, but no margin in the outgoing fine gold.

G. Handling Losses

a. *Wind losses.*—Wind does not cause as much trouble in a refinery as in a smelter, owing to the nature of the material handled. If the atmosphere were absolutely quiet, however, it is conceivable that the fume losses from stacks would settle down within the confines of the plant. Dust collected from the roofs of the buildings is always high in grade although very small in quantity. I have a memorandum of a sample of so-called dust swept up near a refinery furnace building which ran 65.81 per cent Cu, 49.8 oz. per-ton Ag and 3.41 oz. per ton Au.

b. *Theft.*—A refinery is always subject to losses by pilfering and a most thorough system of patrol, passes, etc., together with a policy of prosecution of all cases detected is necessary to hold this in check. Copper is a very easy metal to sell as junk and systematic carrying away of small quantities in lunch pails, etc., may run into surprising amounts. In the silver refinery it is customary to bond the employee and to have a double set of dressing rooms with different clothes for work and for outside wear, the men passing stripped before a watchman from one room to the other. One assistance in the detection of silver and gold thefts lies in the fineness of the products. When a man offers 999 silver or 24 carat gold for sale he at once arouses suspicion.

c. *Solution losses.*—Although the day has passed when electrolytes were purified by running a proportion to the sewer at regular intervals, there is still plenty of opportunity for loss in the handling of solutions.

It is very difficult to keep the electrolyte with its free sulphuric acid confined to the circulating system on ac-

count of tank leaks, overflows, etc., and it is even more difficult to build a permanent water-tight acid-proof floor under these tanks.

Some of the earlier refineries suffered severely from such losses and I know one plant where it was possible to dig a well anywhere in the vicinity and pump out water which gave a profitable copper recovery when passed over scrap iron.

One good way to keep track of losses from this and similar sources is to keep a careful record of sulphuric acid movements in the solutions. Serious acid losses point at once to equivalent copper solution losses. In plants where waste liquors are worked up by cementation upon iron there is an additional opportunity for loss in undertreated waste liquors.

d. Soil losses.—Where a plant is unpaved there is always more or less metallic material ground into the earth and in a smelting plant the top soil becomes in time very good ore. In fact some of the smelters have been smelting this material during the recent high metal prices. In a refinery there is not the same opportunity for loss owing to the nature of the material handled and such a loss should be negligible except in the case of solution losses mentioned above and that of slimes losses taken up below.

e. Slimes losses.—Mechanical losses of slimes could, of course, be assigned to the several sub-headings preceding, but the matter is so important that a separate paragraph has been reserved for their discussion.

Slimes originate in the tank house. They are periodically sluiced down into a screening tank whence they are usually transferred by pumping to a receiving tank in the silver refinery. A certain amount is carried out in the cathodes, a matter which has already been taken up. More or less adheres to the anode scrap when it is drawn and is removed as thoroughly as possible by scrubbing or by high-pressure water-sprays before the scrap is sent to the anode furnace. Any carelessness here may result in wind and soil losses in transit or up the stack during melting.

Tank leaks in the tank house carry considerable quantities of slimes to the cellar floor. While most of these values are recovered by washing the floor, some is absorbed and the floor material has to be smelted whenever extensive repairs are made.

In the silver building the slimes of necessity get spilled around to a certain extent and as boiling operations are conducted in this department the steam makes a sort of paste with them and care must be taken that all unnecessary walking in and out of this department be avoided, and that proper means for wiping shoes be provided. The shower baths used by the workmen should drain into the general wash water system.

The very best possible floor must be provided in this building. During some changes in one of the silver refineries some old foundations yielded up an absorption of 17,000 oz. of silver and 200 oz. of gold.

The slimes before melting have the appearance of black mud and it is very hard to get workmen to handle them with the care they instinctively give to the silver sponge and other metallic products produced later.

From the foregoing it will be appreciated that constant thoughtful attention in a great many directions is necessary to make a minimum metal loss. As the precautions all cost money it raises the question whether the additional saving due to them pays. The answer to this is that it is only by constant schooling in all these precautionary measures that men can be trained to be really careful when they are on their own responsibility and not under observation. For this reason the liberal use of white paint and many other seeming extravagances are justified. The same rigid care and supervi-

sion in the weighing, sampling, and assaying is required as in the control of slag and cathode losses, and careful attention must be given on general principles to all the apparently insignificant sources of indefinite loss.

The Formation of Aromatic Compounds from the Cracking of a Gas Oil

BY GUSTAV EGLOFF AND THOMAS J. TWOMEY

The commercial yields of aromatic compounds from the thermal decomposition of a gas oil at atmospheric pressure have not been given in the literature, although many processes as the Pintsch gas and oil gas machines have been using gas oil for years, forming the products aliphatic and aromatic hydrocarbons, permanent gases and carbon. The enormously increased demand for the substances benzene and toluene, due to the European war, emphasizes the necessity of having clear-cut information as to the number of gallons of benzene and toluene which would be produced from 100 gal. of gas oil used. It is hoped that this research will add to our information as to the yields of the aromatic hydrocarbons, benzene and toluene, from the cracking of a gas oil at atmospheric pressure and various temperatures at constant rate of oil flow into the cracking area.

The gas oil was pumped from a storage tank, passing through a calibrated oil meter into a gas-heated steel tube of 11.6 ft. in length and 8 in. in diameter, which was held at the temperature of the experiment. The gas oil was immediately vaporized in the upper portion of the tube, and the vapor passing through the heated zone was cracked into lower boiling aliphatic and aromatic hydrocarbons, permanent gases and carbon. The cracked vapor in part passes downward out of the sphere of the reaction through a coil condenser, the balance condenses in the air-cooled carbon pot at the bottom of the steel tube. The cracked oil from the condenser and carbon pot are mixed and a sample taken for analysis.

The oil used is what is termed commercially a gas oil derived from Pennsylvania crude petroleum. The gas oil had a boiling range of 90 per cent between the temperatures 200 deg. C. and 350 deg. C. The specific gravity of the starting oil at 15.0 deg. C. was 0.841, using a Westphal balance. The distillation was made with a Standard 100 c.c. Engler flask.

Temperature	Per Cent by Volume	Specific Gravity
0°—200° C.	3.9	
200°—250° C.	8.9	0.768
250°—300° C.	46.2	0.823
300°—350° C.	35.4	0.849
Residue	5.6	

In each experiment 20 gal. of oil were used.

The oil was cracked at five temperatures, 1100 deg. Fahr., 1200 deg. Fahr., 1300 deg. Fahr., 1400 deg. Fahr. and 1500 deg. Fahr. The gallons of oil flow into the cracking area was held approximately constant at 12 gal. per hour. In each experiment the number of gallons used was 20, and was measured with an oil meter which had been calibrated. The temperature of the reaction was determined by the use of a pyrometer, and registered the temperature upon the outside of the steel tube. Very careful temperature control was maintained as far as practical. The temperature variation was never greater than plus or minus 10 deg. Fahr.

The analysis of the cracked oil was conducted according to a method devised by the authors.¹ The procedure was to distill the cracked oil by use of an efficient fractionating column to 170 deg. C. This cut is refrac-

ated and analyzed for its benzene, toluene and xylene content by distillation cuts and specific gravity.

The specific gravities of the cuts were taken by means of a Westphal balance at 15.0 deg. C.

Experimental Data

The experimental data follows in the form of tables and graphs.

Table 1 and Fig. 1 show the effect of temperature on the per cent of recovered oil and specific gravity of recovered oil.

TABLE 1—THE EFFECT OF TEMPERATURE AT ATMOSPHERIC PRESSURE ON THE PER CENT OF RECOVERED OIL AND THE SPECIFIC GRAVITY OF RECOVERED OIL

Temp.	Per Cent of Recov. Oil	Specific Gravity
1100° F.	72.0	0.857
1200° F.	60.3	0.883
1300° F.	44.5	0.935
1400° F.	39.0	0.979
1500° F.	34.5	0.987

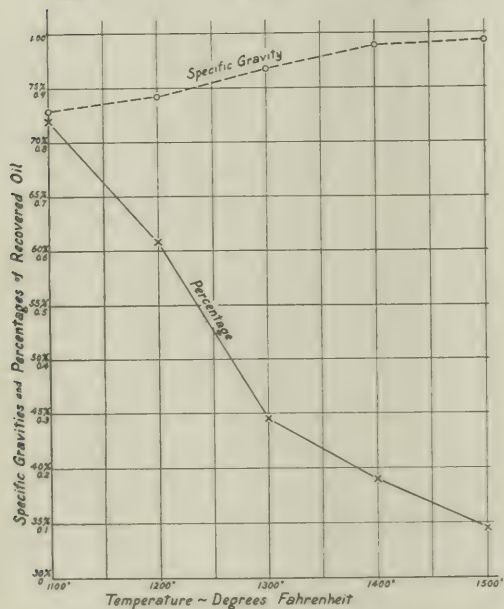


FIG. 1—THE EFFECT OF TEMPERATURE AT ATMOSPHERIC PRESSURE ON THE PER CENT OF THE RECOVERED OIL AND THE SPECIFIC GRAVITY OF THE RECOVERED OIL

TABLE II—THE EFFECT OF TEMPERATURE ON THE FORMATION OF BENZENE, TOLUENE AND XYLENE IN THE RECOVERED OIL

Temp.	Per Cent Benzene	Per Cent Toluene	Per Cent Xylene
1100° F.	0.4	2.0	2.2
1200° F.	0.9	3.0	3.1
1300° F.	4.1	6.7	7.2
1400° F.	8.4	8.5	8.8
1500° F.	8.5	7.0	8.8

TABLE III—THE EFFECT OF TEMPERATURE ON THE FORMATION OF BENZENE, TOLUENE AND XYLENE ON THE BASIS OF OIL USED

Temp.	Per Cent Benzene	Per Cent Toluene	Per Cent Xylene
1100° F.	0.3	1.4	1.5
1200° F.	0.6	2.1	2.1
1300° F.	1.8	32.8	2.2
1400° F.	2.2	32.2	2.2
1500° F.	2.6	32.3	2.2

Table 2 and Fig. 2 show the effect of temperature on the formation of benzene, toluene and xylene in the recovered oil.

Table 3 and Fig. 3 show the effect of temperature

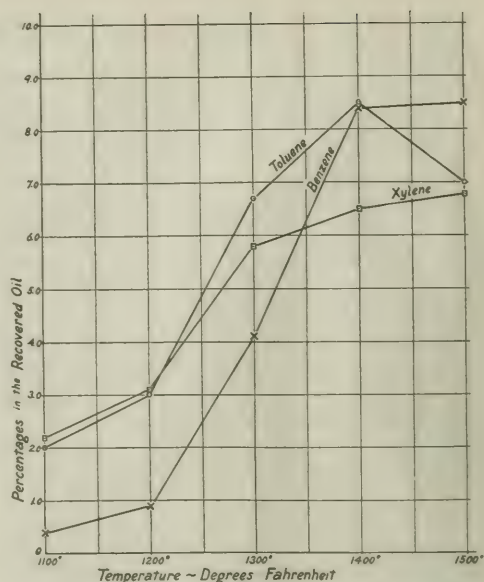


FIG. 2—THE EFFECT OF TEMPERATURE ON THE FORMATION OF BENZENE, TOLUENE AND XYLENE IN THE RECOVERED OIL

on the formation of benzene, toluene and xylene on the basis of oil used.

Table 4 and Fig. 4 show the effect of temperature on the distillate to 170 deg. C. and the specific gravity of the distillate.

Table 5 and Fig. 5 show the effect of temperature on the specific gravity of the benzene, toluene and xylene cuts.

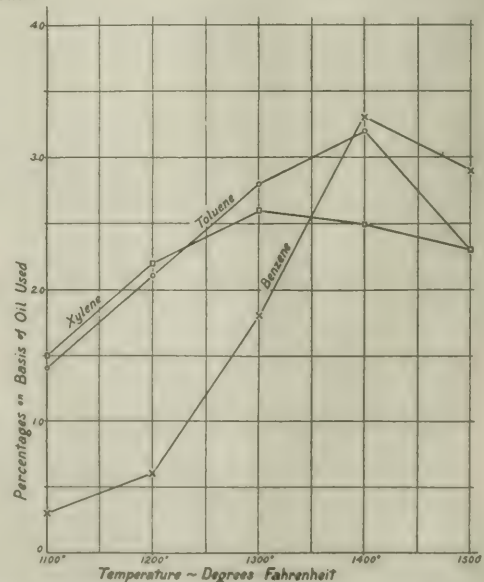


FIG. 3—THE EFFECT OF TEMPERATURE ON THE FORMATION OF BENZENE, TOLUENE AND XYLENE ON THE BASIS OF OIL USED

Discussion of Experimental Data

A. THE EFFECT OF TEMPERATURE ON THE PER CENT OF RECOVERED OIL AND SPECIFIC GRAVITY OF RECOVERED OIL

A paraffin base oil when subjected to thermal decomposition in the vapor phase yields permanent gases, carbon, and a liquid which is widely different in constitution from the original starting oil. It contains some high molecular weight paraffins; lighter molecular weight paraffins; olefins and aromatic hydrocarbons of the type benzene, toluene and xylene.

From Fig. 1 it will be noted that as the temperature increases the decomposition of the oil increases, most markedly between the temperatures 1200 deg. and 1300 deg. Fahr.

The specific gravity of the cracked oil increases with increase of temperature. At 1100 deg. Fahr only a slight difference will be noted from the gravity of the starting oil. This would indicate that only a small amount of cracking takes place at this temperature. The greatest change takes place between the temperature limits of 1200 deg. and 1300 deg. Fahr., which are also the temperature limits which give the highest decomposition of the original oil.

B. THE EFFECT OF TEMPERATURE ON THE FORMATION OF BENZENE, TOLUENE AND XYLENE IN THE RECOVERED OIL

In the thermal decomposition of gas oil the formation of xylene proceeds more rapidly than either benzene or toluene at the lower temperatures. As the temperature is increased to 1400 deg. Fahr. the benzene and toluene content of the recovered oil increases rapidly, whereas

the xylene falls off considerably. The maximum amounts of benzene, toluene and xylene are: 8.5 per cent benzene at 1500 deg. Fahr.; toluene, 8.5 per cent at 1400 deg. Fahr., and 6.8 per cent xylene at 1500 deg. Fahr.

C. THE EFFECT OF TEMPERATURE ON THE FORMATION OF BENZENE, TOLUENE AND XYLENE ON THE BASIS OF OIL USED

Commercially the interesting and most important fact of cracking gas oils at present are: how many gallons benzene, toluene and xylene can one make from 100 gal. of gas oil? The maximum formation of benzene was found to be 3.3 gal. per 100 gal. of oil used. Toluene yield was 3.2 gal. and xylene 2.5 gal. for each 100 gal. of oil used. In other words, 9 gal. of valuable aromatic compounds from 100 gal. of paraffin-base gas oil.

D. THE EFFECT OF TEMPERATURE ON THE DISTILLATE TO 170 DEG. C. AND THE SPECIFIC GRAVITY OF THE DISTILLATE

The light oil distillate to 170 deg. C. contains all of the benzene, toluene and xylene. It will be noted that as the temperature increases the per cent of distillate to 170 deg. C. increases to a maximum and then decreases. The gravity also increases with increase of temperature, and indicates the greater decomposition of the paraffin hydrocarbons to aromatic compounds.

E. THE EFFECT OF TEMPERATURE ON THE SPECIFIC GRAVITY OF THE BENZENE, TOLUENE AND XYLENE CUTS

The specific gravity of the cuts of benzene, toluene and xylene indicates the relative freedom from like boiling point hydrocarbons of the paraffin series, which

TABLE IV—THE EFFECT OF TEMPERATURE ON THE DISTILLATE TO 170° C. AND THE SPECIFIC GRAVITY OF THE DISTILLATE

Temp.	Per Cent to 170° C.	Specific Gravity
1100° F.	20.8	0.770
1200° F.	25.8	0.788
1300° F.	28.7	0.823
1400° F.	29.1	0.850
1500° F.	27.6	0.850

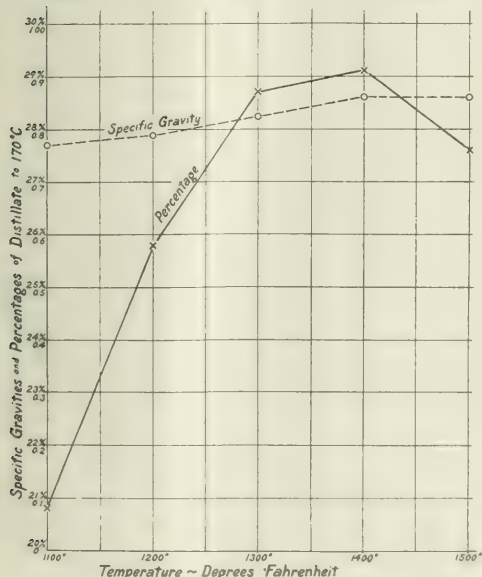


FIG. 4—THE EFFECT OF TEMPERATURE ON THE DISTILLATE TO 170 DEG. C. AND THE SPECIFIC GRAVITY OF THE DISTILLATE

TABLE V—THE EFFECT OF TEMPERATURE ON THE SPECIFIC GRAVITY OF THE BENZENE, TOLUENE AND XYLENE CUTS

Temp.	Benzene Sp. Gr.	Toluene Sp. Gr.	Xylene Sp. Gr.
1100° F.	0.734	0.787	...
1200° F.	0.740	0.798	0.816
1300° F.	0.796	0.840	0.850
1400° F.	0.850	0.866	0.875
1500° F.	0.874	0.864	0.867

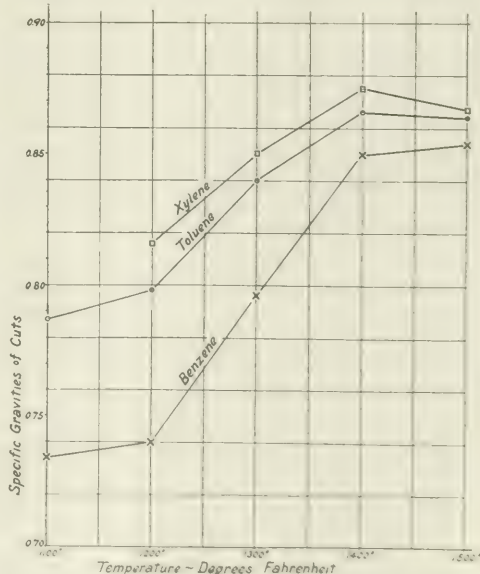


FIG. 5—THE EFFECT OF TEMPERATURE ON THE SPECIFIC GRAVITY OF THE BENZENE, TOLUENE AND XYLENE CUTS

cannot be removed by any physicochemical means. Trinitrotoluene and phenol can be readily made from the toluene and benzene which are formed from the decomposition of a paraffin-base gas oil.

SUMMARY

1. The greatest decomposition of the gas oil used takes place between the temperatures of 1200 deg. Fahr. and 1300 deg. Fahr.

2. The maximum amounts of benzene, toluene and xylene in the recovered oil are: benzene, 8.5 per cent at 1500 deg. Fahr.; 8.5 per cent toluene at 1400 deg. Fahr., and 6.8 per cent xylene at 1500 deg. Fahr.

3. It has been shown that at atmospheric pressure and 1400 deg. Fahr. in a steel tube 11.6 ft. in length and 8 in. in diameter, that 100 gal. of the gas oil used will produce 3.3 gal. of benzene, 3.2 gal. of toluene, and 2.5 gal. of xylene.

4. It has been shown that the benzene, toluene and xylene, relatively free from paraffin hydrocarbons, can be produced from the cracking of a gas oil.

Electrochemical Possibilities of the Pacific Coast States as Compared with Those of Sweden and Norway*

BY J. W. BECKMAN

To some of us the word electrochemistry has a mystic charm; it produces visions to the mind's eye of turbulent streams and waterfalls in the midst of peaceful forests, and also the vision of the electric furnace with its sputtering frenzy. It is a wide step from the waterfalls in the woods to the wild roaring of an electric furnace, but we all know that they stand in intimate relationship to each other. The power of the impetuously falling water is harnessed and transferred often hundreds of miles, silently and calmly over a wire, only to be let loose at the other end in often a wild though conquered shape, to produce products which a complex civilization has learned to be dependent upon.

To-day there may be dreamers who have visions of cheap electric power being produced in a way other than by water power. It may be possible to do this, but for the big electrochemical industries of to-day, and of the future, hydraulically produced power is and will be used. Therefore, the most important raw materials of all electrochemical industries is an abundant amount of water seeking a lower level. Few locations offer conditions favorable to the harnessing of water for industrial purposes, and as a rule the mountainous countries are the water-power producing localities.

Lands that are known as hydroelectric power producers are various mountainous sections of Southern Europe as well as Sweden, Norway, and Finland in Northern Europe. The Western sections of the North and South American continents are, together with New Zealand and a few other localities, favorable to hydroelectric power developments.

It may seem strange to compare Sweden and Norway, countries old in the civilized history of the world, and from our point of view located on the globe practically at the North Pole, with the three Pacific Coast States, California, Oregon and Washington, but I believe there are many similarities, in spite of difference in relative position on the globe, that are in many respects quite startling.

I beg you to note that Sweden and Norway are about as large as the three States of Washington, Oregon

and California. The population in Sweden is about five millions, and the three coastal States contain practically the same number.

Sweden has large sections along the coast which are comparatively flat, consequently the water power sites are located mainly inland, much the way conditions are on the coast. One-half of Sweden is wooded, while half of these three States is under timber.

Geologically the conditions are very different. Sweden is practically all of very ancient geological formation, while the coast is, as we all know, of comparatively recent formation.

In a general way conditions in Norway are similar to those in Sweden. The land is heavily timbered and filled with inaccessible mountains and valleys. In many places the streams drop right into the ocean, making power developments possible on tidewater, similar to the possibilities on our own coast in British Columbia and Alaska. The geological formation in Norway is of the same age as in Sweden. Norway has about three million inhabitants, making a total of eight million inhabitants on the Scandinavian Peninsula.

The electrochemical possibilities in Sweden and Norway are great for two reasons only—one is abundance of cheap power, the other is comparatively cheap labor.

Seven and one-half million horsepower are available in Norway at present, of which one-half million is developed, and an additional million horsepower is under development. When this power is developed it will amount to about 20 per cent of all available power.

The largest present, single operating installation is at Rjukan, where 131,000 hp. are developed and at the same place 119,000 hp. are being developed, which is the largest power development under way there at present.

There are two developments possible in Norway, each for 240,000 hp., but neither of them is even projected to be developed. Many of the installations are in the interior and inaccessibly located, involving special means of transportation to reach them, often through sections of the country where power transmission is impossible, partly due to the nature of the country, and also due to climatic conditions.

However, in Sweden conditions are materially different. The heads are comparatively low and the nature of the country makes long transmission lines possible. The available power in Sweden is 6.2 million hp., of which at the present time 900,000 hp. are developed, about 15 per cent of total available power.

The largest single development in Sweden is that of the Swedish government at Trollhättan, in the Southern part of the country, where a total of 80,000 hp. is obtainable. The greater part of the Swedish developments are low-head and small-capacity plants.

If the power situation be considered in the Pacific Coast States, it will be found that there are available about 11,000,000 hp., of which 7 per cent or 831,000 hp., have been developed. Most of the developments are high-heads, 500 ft. or more—a few exceptions there are—and among the most noted proposed low-head developments on the Pacific Coast is The Dalles development on the Columbia River, where about 800,000 hp. could be delivered. More than half this amount could be supplied twelve months of the year. The remaining power could be counted on for eight to eleven months of the year.

The Great Western Power Company is, in spite of having developed some 100,000 hp., still able to develop some 500,000 hp.

On account of local and climatic conditions in the

*A paper presented before the San Francisco Section of the American Chemical Society.

coastal states, long distance transmittal is easy and comparatively cheap.

As the population is centered in the large valleys and along the coastal districts, the necessary length of power lines from generating stations, located in the mountains, to the consuming districts, are comparatively short, and the lines with few exceptions do not exceed 200 miles.

The cost of hydroelectric power is really a question of bookkeeping, and since each individual power plant has its pet way of calculating costs, it is impossible to compare the average power costs given with each other, not knowing how much, or how little, they include, what the interest rates are, etc. When a standard accounting method is adopted by all power plants all over the world, then the comparing of cost, per horsepower, may have some meaning.

When an industry develops its own power source, the bookkeeping method can hide absolutely the actual cost of the power. On this account I am extremely sceptical as to the low figures quoted for the power some industries utilize in Norway.

The prices for power obtainable on this coast close to, or at the power site, do not vary materially from those in Sweden and Norway.

The prices in those countries are from about \$6 per horsepower-year, and up, provided large blocks of power are taken. In Norway with higher head developments the minimum price may be somewhat lower.

Compare these prices with that of less than \$10 per horsepower, quoted by the State of Oregon for power from the projected development at The Dalles, and I believe it will be agreed that cheap power is available here, as well as in Sweden and Norway.

Only recently the Great Western Power Co. has entered into contract with an electrochemical company, for large blocks of power on tidewater at a rate that is as good as that which is obtainable at Niagara Falls. Niagara Falls is 500 miles from tidewater, which means a long rail haul. Power on San Francisco Bay at the same rate, means large savings in the way of transportation charges, etc.

The idea that there is an abundance of cheap labor in Sweden and Norway is to an extent a fallacy. Emigration is continuously draining the working stock of the people, and although the average daily wage is about \$1 to \$1.25, there is not a superabundance of labor, and the industries are often handicapped. Of course, in the more specialized industries, as the electrochemical, the price for labor is somewhat higher.

Compared with the cost of labor on the Pacific Coast, the Scandinavian prices are low. But the ultimate cost of producing electrochemical products, I believe, is no higher there than here, due to higher cost of raw materials there than we have to pay.

What, then, are the industries that have brought Sweden and Norway to the front in the eyes of the world as countries that take a foremost position in the electrochemical industries?

When artificial nitrogen fertilizers are mentioned, Norway with its nearly 300,000 hp., exclusively devoted to that industry, looms up. Calcium nitrate and calcium cyanamide are both products made in Norway; the latter is also made in Sweden. The raw materials for these products are: cheap power, the nitrogen of the atmosphere, and limestone. In case of the cyanamide, coal is also needed. In Sweden and Norway, plentiful, cheap power is available, though not always in accessible places as the large developments at Rjukan, in Norway show, located as they are in the most impenetrable part of the mountain fastness. Nitrogen is abundant; lime-

stone is accessible, in some cases, though involving considerable haul by rail or water. The coal is all brought in from England, which means expense of handling and in addition duty on the importations.

The Pacific Coast States are in this respect as favored in many instances, as the countries of the Scandinavian peninsula. Take, as an example, the projected development at The Dalles; deep-water navigation is possible up to and beyond the proposed power site; limestone from Washington could be brought in cheaply, quarried as it is right on tidewater; coal from China, and eventually from Alaska could also be brought in and water transportation would be available for the finished product.

Similar conditions can be found at other localities on the Pacific Coast.

What has been said in regard to the fertilizer industries applies equally well to the carbide industries. Sweden consumes some 20,000 hp. annually in carbide manufacture and Norway, though I have no definite figure, consumes considerably more at the large works at Odda.

The Swedish iron is famous and well known over the world. There was a time, however, until quite recently that Swedish iron was beginning to lose its reputation. Scarcity of charcoal followed the increasing numbers of shaft furnaces in operation until gradually some of the iron masters of Sweden began to substitute coke with charcoal and the common coke pig iron was obtained with a result that the long established position held by Swedish iron in the markets of the world was fast slipping away. To-day, though, it is possible to increase the number of shaft furnaces in Sweden to three times as many as at present, without being obliged to use coke.

The reason is the introduction of the electric shaft furnace, in which two-thirds of the charcoal used for heating the charge in the furnace are replaced by electric heat. As the earliest blast furnaces were built in Sweden, so also Sweden first successfully solved the electric shaft furnace.

The iron industry of Sweden is located in a narrow strip 70 miles wide and 140 miles long approximately, the distance from Oakland to Sacramento. This small section of the country has brought, through its iron, fame to Sweden. As time goes along and the old blast furnaces have to be replaced with new, never again will an old-type furnace be placed in operation. Electrical shaft furnaces will be installed instead. There are now over a dozen of these furnaces in operation in Sweden turning out close to 50,000 tons of iron per year. The raw materials needed in electric shaft-furnace operations are cheap power, high-grade iron ore, good limestone and an abundant supply of charcoal.

Close to 1,000,000 tons of charcoal are burnt in Sweden annually, a great part of which is used in the iron industries. The charcoal is burnt all over the country and shipped into the iron-producing district by rail.

The greater part of the charcoal is produced in the old-fashioned way of heap-burning, though there is a strong tendency at present to replace the heap-burning by the large-unit by-product charcoal ovens, of which there are over twenty plants installed and operated. In this connection let me mention that at the Panama-Pacific Exposition there was a very excellent exhibit in the Swedish Building, of raw materials used and finished products obtained from one of these by-product plants.

Norway is also heavily timbered, but due to very great transportation difficulties charcoal is not produced in such quantities there, nor do I believe they have any electric shaft furnaces in operation.

The iron ore is abundant in Sweden. Some has to be concentrated, since high contents of silica mean an excessive power consumption in the electric shaft furnace. The Northern ores from the large famous deposits near the Arctic circle average close to 70 per cent iron, and so do the concentrates from the more centrally located deposits.

Limestone is available though not always in close proximity to the shaft furnace plant.

Power is very often obtained from small hydroelectric developments, where enough energy is generated to operate a single furnace or purchased from a generating station.

What then are the conditions on the Western coast of the United States that would suggest the possibility of an iron industry growing up similar to that of Sweden.

The three coastal States have practically as much timber land as Sweden; the actual board measure would be much to the advantage of these States, since, due to climate and other conditions the growth in Sweden is quite light. Incidentally it is of interest to realize that Washington, Oregon, and California to-day contain about one-half of all the timber lands in the United States. There are twenty-eight hundred billion feet of timber in the United States, while these three States have of this amount thirteen hundred billion feet.

By-product charcoal plants, close to the large lumber operations, should at present not only be the wise policy for lumber operators to follow, but should also give a good revenue from what at present is a decided nuisance and often a menace, and supply the needed charcoal for iron reduction.

It would take many years to develop 1,000,000 tons of charcoal per year on the West coast, but it is interesting to note that under conditions considerably adverse to our own this has been accomplished in Sweden.

Limestone is abundant all through the States, the quality of which is suitable for smelting purposes.

Iron ores of varying qualities, some of the highest purity, and others less pure, are available at many points in California and in adjoining States.

Power close to power sites and in the timbered districts, where charcoal could be cheaply made, is obtainable at prices which will make electric shaft-furnace operations not only successful, but financially profitable.

Norway and Sweden produce small amounts of ferroalloys. The raw materials have to be imported. As an example, chrome ore is brought in from New Zealand.

The raw materials for such industries are right at hand in these States and can be had, in many cases, practically at no cost compared with prices paid for similar raw materials brought into Sweden and Norway.

Norway produces some aluminium from ore, part of which is imported and part is obtained from local deposits.

The Pacific Coast States have a very large supply of practically pure aluminium oxide awaiting treatment in waste piles, the aluminium oxide being a by-product in the potash production from alunite. Utah is one of the States where this by-product is produced.

Sweden produces considerable quantities of sodium and potassium chlorate. The raw materials have to stand heavy freight charges as they are imported from Germany. This is also the case in reference to salt used in the manufacture of caustic soda and bleach.

We are favored here by salt, which is readily available. It may be of some interest to know that a caustic soda and bleach plant is being built on San Francisco Bay.

Potassium chloride is to be had from Searles Lake,

we hope at no very distant date. Meanwhile we may be able to get this salt from various waste materials available on the Pacific Coast, which are now being absolutely neglected.

An industry of special interest developed in Sweden is the electric reduction of zinc. Not less than 18,000 hp., producing close to 4000 tons of zinc per annum, are consumed in this industry. Ores containing both lead and silver, as well as zinc, are used in recovering the values.

Many of the ores of the West, which are now deemed practically worthless due to zinc content, could be advantageously treated in the electric furnace on the Pacific Coast.

An industry can never be a success if there is no market for its products.

Sweden and Norway together have a population, as mentioned before, of about 9,000,000 people, and since the greater part is a rural population there is a comparatively small demand for manufactured products. Therefore, foreign markets have been sought for the products of the industries.

There is no part of the globe that is not in some way dependent on products made in Sweden and Norway. This wide market field has been developed through necessity and necessity has forced co-operation. Commercial agencies have been formed in foreign ports through which everything from Swedish lumber, sewing machines to electrochemical products have been sold. The different manufacturers have maintained these sales agencies jointly and consequently the selling cost in foreign countries has been brought down to a minimum for the various products.

The nearby European markets are severely competitive, but they have been entered successfully. This has been possible for two reasons: quality of product and price of product.

Sweden and Norway, the latter especially, have learned the art of handling tramp steamers. Due to this fact freight rates for products reaching foreign markets have been brought to a minimum.

It is equally possible for electrochemical industries, or, in fact, any industry on the Pacific Coast to penetrate foreign markets. We can reach from this point over one-half of the world's population by going West and South. Some of the markets are small, but are bound to grow, and if we miss the present opportunity somebody else will step in and collect the harvest which legitimately belongs to us.

The large electrochemical developments in Norway are financed by international capitalists, involving various complex problems, while here, if the needed capital cannot be procured on the coast, projects may be jointly financed by local as well as Eastern capital. This involves at the most a trip East with none of the complications that go with the use of foreign capital.

The Pacific Coast is endowed with raw materials that may in time revolutionize some of the large industries; take, for example, oil so abundantly present in California.

Doesn't it seem like the intention of fate that large high-grade iron ore deposits, hydroelectric power and oil have been placed side by side? Can't we conjure up a new type of iron-reduction process where the iron is obtained from the ores by means of electric heat combined with the carbon and hydrogen in the oil, as reducing agent? I feel certain that the day will come when the Pacific Coast will be a factor in the iron markets of the world, due to the presence of these three agents.

Norway has about 500,000 and Sweden practically 150,000 hp. utilized in electrochemical and electrometal-

lurgical industries. These have not grown over night. On the contrary, careful and faithful pioneer work had to be done not only in the laboratories, but among the population, and also in the Council Chambers of the nation. An electrochemical atmosphere has been produced; the layman has been brought face to face with it in perusal of his daily paper and gradually the population has grasped the fact that (though the details are perhaps hidden to the layman) electrochemistry is one of those mystic shrines by which, if treated with the correct signs known only to a few, new developments and wealths are produced.

We need an electrochemical atmosphere on the Pacific Coast. Up to the present time gold mining has been the atmosphere. Everybody knows what a placer mine or a gold dredge is; the papers are full of it. The large State universities of the coastal States as well as the daily papers, can assist in bringing this electrochemical atmosphere here.

Without fear of being refuted I will say that the Pacific Coast has more potential wealth in its 11,000,000 hp. of water power, of which 93 per cent goes to waste to-day, than all the gold that ever was mined or is still to be mined in these States.

Sweden and Norway are to-day looked upon as electrochemical centers. The Pacific Coast, I believe, will, within the lifetime of most of us, be looked upon as one of the large electrochemical centers of the world due to our being favored with abundant hydroelectric power and the varied and important raw materials needed in these industries and due to the enterprise of the men of this coast.

Electrochemistry is a young science in its present development compared with other sciences. The electrochemical industries are consequently young men's industries. Therefore, young men are needed, men with the pioneer's optimistic resourcefulness and courage. But this alone is not sufficient; they need a special education which the large universities of this coast are bound to give if they are not already giving it to their students.

With the power, the raw materials and the men the Pacific Coast holds a mighty future in the field of electrochemistry.

Great Western Power Company,
San Francisco, Cal.

The Draeger Oxygen Apparatus Co., Pittsburgh, Pa., have placed on the market a new pulmator which is designed type "B." A pamphlet has been issued by the company describing the many advantages of this new type.

Increase in Japanese Zinc and Aluminium Industries.—Considerable activity is being manifest in Japan in the zinc and aluminium industries. According to Commerce Reports the recent development of the zinc-refining industry has brought considerable increase in the output of zinc ores. The total output is expected to be more than 10,000 tons per year, as compared with 40,000 tons before the war, when the refining mills were mainly dependent on supplies from Australia. The Japan Aluminium Manufacturing Co., which has recently been floated by Tokyo, Osaka and Nagoya capitalists with capital of 1,000,000 yen (\$498,500) is building a factory at Rokuga-mura, a suburb of Nagoya. It is to be completed in the course of July, and operations are to be started in August. The management of the company intends at the start, the Japan Chronicle states, to turn out about 250 tons a year. The Japan Aluminium Co. intends ultimately to increase the capital to 10,000,000 yen (\$4,985,000) with the object of turning out 25,000 tons a year, that is, the total quantity needed in Japan.

The Rate of Driving the Blast Furnace

BY J. E. JOHNSON, JR.

One of the most important items in the control of furnace operation is the rate of driving. This is to say, how much iron we should attempt to make per day from a given furnace which depends, other things being equal, upon the amount of coke we burn and that in turn on the amount of blast we blow per unit of time. The best rate must be determined with reference to two sets of considerations, one technical and the other commercial.

The technical ones are: first, effect upon the regularity of the settling of the charge; second, the effect upon fuel consumption; third, the effect upon the power required for blowing; fourth, the effect upon flue dust lost; fifth, effect on the life of the lining. The commercial ones are: first, the effect upon profit, since other things being equal the annual profit is proportional to the tonnage produced; second, the effect upon costs other than fuel cost, principally labor and overhead, since these costs per ton are, other things being equal, inversely proportional to the output; third, the effect upon the value of the power consumed for blowing. This distinction between technical and commercial considerations is more or less arbitrary since all these considerations are partly one and partly the other, but the distinction is permissible to facilitate the more technical treatment of the subject now, leaving commercial considerations to be discussed in a later chapter.

Effect on Descent of Charge

The effect of the rate of driving upon the regularity of the descent of the charge is placed first because it is of capital importance and affects every other item. Without regularity of descent of the charge we cannot steadily maintain the production of the most profitable grades of iron, we cannot secure the maximum monthly output, we cannot, above all, secure highest fuel economy, and, finally, without it we cannot keep our flue dust losses within any reasonable limits, when running on fine ore.

Reverting to the article on the physical action of the blast furnace it will be seen that the resistance to the passage of the gas rises as the fourth power of the quantity of blast blown, so that from our pressure chart it can be shown that while a 22 x 90-ft. furnace, blown with 45,000 cu. ft. of wind, requires about 13 lb. blast pressure, the same furnace blown with 55,000 ft. of wind would require about 17½ lb. pressure. As pointed out in that article, these figures are both probably a pound or so low, but this fact only exaggerates the difference.

From the conclusions reached as to the relatively accurate balance between the weight of the charge and the forces supporting it, it will be seen that a change like this of almost 50 per cent in blast pressure might easily result in disturbing the floating equilibrium between weight and resistance, and so result in hanging the charge column or some portion of it lying above a tight zone. This would result in slipping, with all its attendant evils—reduced output, poor and irregular quality, higher fuel consumption, and all the rest—these results, of course, being in some rough degree proportional to the seriousness of the slipping caused.

The Effect of the Rate of Driving on Fuel Consumption

This is a very complicated matter. In the early nineties, when outputs were on the average less than half of what they are to-day, it was supposed that the maximum rate of driving, consistent with economy, had been reached. In the interval which has elapsed since,

we have seen a much more rapid rate of driving accompanied by a much higher fuel consumption, but this has been succeeded in more recent years by a marked reduction in fuel consumption, so that the best of to-day is better than that of any past time, irrespective of the rate of driving.

In order to make an adequate comparison it is necessary to have a measure of the rate of driving. This is quite generally taken as the number of pounds of coke burned per hour per square foot of hearth area, so that if a furnace with a 16-ft. hearth were burning 480 tons of coke per day, that is, 20 tons of 2000 lb., or 40,000 lb. per hour, the area of a 16-ft. circle being 200 sq. ft., the rate of combustion is 200 lb. per square foot per hour.

It is commonly considered that 250 lb. per square foot is about the maximum amount consistent with good work, and this figure is in fair agreement with most practice of to-day, though I have operated furnaces burning over 300 lb. per square foot with excellent results in fuel economy for the given conditions. On the other hand, the large-hearth furnaces with which very economical results have been reached in very recent years are only burning about 40,000 lb. of coke per hour in a 17½-ft. hearth, which is less than 200 lb. per square foot.

It has seemed to me that this basis of comparison was not altogether a correct one. I have endeavored to show in the earlier articles that the real combustion space of the furnace was not a single plane at the tuyeres, but that combustion was going on throughout the bosh, that is, from the tuyere plane to the top of the bosh, and in order to obtain truly comparative figures we would rather use the combustion per cubic foot of this space than per square foot of hearth area. On that basis the large-hearth furnaces are really as hard driven as any, for two reasons: First, while the hearth is very much larger than that of other furnaces with the same height and bosh diameter, by this method of figuring this change affects only the smaller diameter of the frustum of an (inverted) cone whose base is the bosh diameter, so that the percentage of change in its volume produced by this increase in its smaller diameter is less than half that produced in the smaller area itself. Second, the wide-hearth furnace has been accompanied by a lowering of the top of the bosh so that its vertical height is decidedly smaller, and this reduces the volume of this zone of the furnace as much as the widening of the hearth increases it.

It is an unfortunate fact that we have no figures for coke consumption per cubic foot of bosh space, and this unit of measure can therefore only be introduced into general use after a considerable campaign to replace the older but less accurate unit.

Concerning the results of the true rate of combustion upon fuel economy we know much less than we should, but some of the factors which affect it may be pointed out. The first of these is the velocity of the combustion of coke in a blast initially air, but burning progressively to CO and nitrogen. A simple calculation shows that the blast can be but a few seconds in passing from the tuyeres to the top of the bosh. The volume of air blown into the modern furnace is about sufficient to fill it twice a minute if the furnace were empty and the air under atmospheric conditions. As a matter of fact the air is increased in volume between three and four times by heating, and this volume is reduced by the compression under which it enters the furnace, this decreasing, of course, as it rises, so that its average pressure is one and a half times atmospheric, while its absolute temperature at the top of the bosh is six or seven times atmospheric, and the average something

like four times atmospheric, hence its actual volume is nearly three times that under atmospheric conditions. This would mean that the furnace, if empty of solid and liquid matter, would be filled six times per minute. But we have seen that if it were filled with uniform spheres the total voids would only be about 25 per cent of the total, and with very irregular material, including much fine, continually settling and thereby reduced to minimum volume, the voids are probably not over a half of this, perhaps much less, so that the voids are probably only about an eighth of the total contents of the furnace. This indicates that the actual gas volume is sufficient to fill the voids at least forty-eight times per minute, so that in about one second the blast which enters at the bottom of the furnace passes through it and is discharged as gas at the top.

Now taking the height from the tuyeres to the top of the bosh as one-eighth or even one-sixth of the total height of the furnace we see that less than one-sixth of a second is available for the complete combustion of the oxygen of the air to CO. Such a velocity makes it impossible that combustion should go on in the interior cells of the coke because it is impossible that the air should penetrate a solid (though porous) structure and make its exit in that time; therefore combustion must proceed only upon the surface of the coke. This is not unlimited, and as we know that an appreciable interval of time is necessary for the complete combustion of air it becomes evident that there is a limit beyond which we cannot drive the furnace and have the combustion completed in the proper zone.

This means that for still faster driving more volume would be necessary to complete the combustion, and, therefore, that this would extend to a higher level in the furnace. All our experience in operation, and all of the chemical and thermal theories set forth in earlier chapters tend to the conclusion that the best work can only be done by keeping the zone of fusion as low as possible. It is impossible to go over all the reasoning which leads to these conclusions here; it is a fact based primarily on experience, and one of the best proofs is that the remarkable work of the wide-hearth furnaces has been built upon and around the principle of keeping the zone fusion as low as possible, and the economy which has been obtained in furnaces in which a low bosh is one of the outstanding features, creates a strong presumption that the lowering of the zone of combustion is at least an important factor in the very economical results obtained.

When furnaces are overblown it is a quite general impression, and I believe an entirely correct one, that the upper zone of combustion rises, in accordance with the above reasoning, and this is accompanied by an increase in fuel consumption. In fact, it must be evident that if the fuel consumption be controlled by the quantity of high temperature heat available, anything which tends to dissipate this limited supply of heat over a wider zone must militate against its concentration, and therefore against fuel economy.

The same reasoning which applies to combustion applies to other reactions which must go on. The reduction of the ore is essentially a task which demands time for its completion in the maximum degree possible in each zone before descending into the next, and as this is the essential condition for the maximum possible oxidation of the gases, on which, as we have seen, the total heat development depends, a sufficient allowance of time for the completest possible reduction of the ore in each zone is an indispensable condition for maximum economy. If the ore descends so rapidly as to reach the hearth without the completest possible reduction, the effect is of the same general kind, but of a much higher

order of intensity. We have in such a case the conditions which led to low fuel economy with the wet ore in the charcoal furnace, described in the article on thermal principles.

So it is with all the other reactions; the decarbonization of the limestone, the complete union of the flux with the impurities of the charge, etc. If sufficient time be not allowed for these we shall pay for it by expending more heat than is absolutely necessary upon bringing about the necessary conditions. On the other hand, we shall see later in the present article that there are heat losses of vast importance which are irrespective of the rate of driving. The furnace is constantly undergoing a loss by radiation and cooling water of some 15 or 20 per cent of its heat, especially of that in the hearth; this is 15 per cent of the total developed when the furnace is running at full speed, which is a convenient measure.

But if the furnace stops, the loss continues at the same rate per hour as long as the zones of the furnace remain at the temperature which they have in operation, so that if the furnace were to be run at 15 per cent of its normal rate we should supply just enough heat to make up for the losses without supplying any for the production of iron; if we ran at 30 per cent of the normal full rate we should, on this basis, lose 50 per cent of the heat produced, and the fuel consumption would accordingly be nearly twice what it is at the normal full rate. If we drive at 45 per cent we lose one-third on the same basis, and so on. The figures used are not intended to be exact, though they are approximate to the best of our knowledge.

This line of reasoning shows that we must not allow any more time for combustion, reduction, etc., than is necessary for those operations. We are not at liberty to increase the economy of the furnace indefinitely by slowing down to obtain more complete reactions, because the purely physical radiation and reduction losses begin to assume an increasingly menacing proportion the slower we run. Obviously, then, if we make some loss by allowing a slightly insufficient time for complete reduction, we may offset it by cutting down the radiation losses in a greater degree. If we were considering only fuel economy, our effort should be to run under the conditions which would make the sum of these two losses the minimum. But we shall see when treating of commercial considerations this is only one factor and sometimes by no means the greatest in the solution of the commercial questions involved, and therefore it would be useless to attempt a solution of the purely technical question involved on so theoretical a basis.

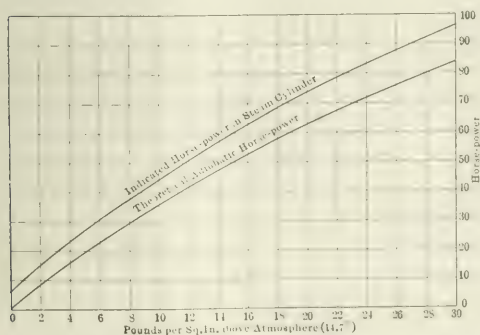


FIG. 1—THEORETICAL AND ACTUAL HORSEPOWERS REQUIRED TO COMPRESS 1000 CUBIC FEET PER MINUTE OF FREE AIR (14.7 LB.) TO DIFFERENT PRESSURES

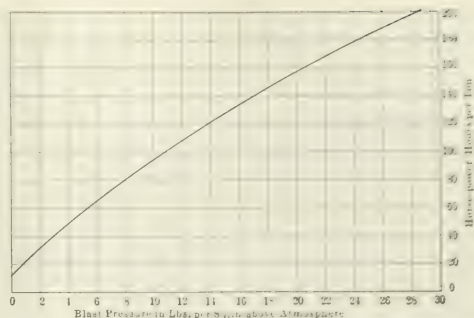


FIG. 2—HORSEPOWER-HOURS PER TON OF IRON PRODUCED REQUIRED TO BLOW FURNACES WITH DIFFERENT BLAST PRESSURES

The Effect on Power Required for Blowing

This is a subject of the utmost importance from two points of view: first, that of the first cost of the blowing plant; second, that of the consumption of gas required to operate it. The time was when the gas was considered of no use or value, but that time is now long gone by, and it is well understood that the gas represents roughly one-half the value of the fuel, in the best and most convenient form, and in modern plants it is applied to the production of power for uses outside the blast furnace and is an asset of great value. Therefore, it is desirable to use as little of it as possible for the blowing of the furnace itself, since power so spent is a necessary evil and nothing else.

The power required for the compression of a given volume of air to a given pressure varies with the type of apparatus used whether steam engine, gas engine or turbo blower.

More data are available in the case of the steam engine, and I have therefore used it for developing the facts in the following discussion. The lower curve of Fig. 1 shows the theoretical power required to compress adiabatically 1000 cu. ft. of air per minute from atmospheric pressure (14.7 lb. abs.) to different pressures. The upper curve shows the actual indicated power required in the steam cylinders of a blowing engine to compress it to the same pressures with normal assumptions based on practice as to the efficiency of the blowing cylinders and the friction of the engine. By assuming now a figure for the amount of air to burn a pound of coke and the amount of coke consumed per ton of iron we obviously can calculate the horsepower-hours per ton of iron with different blast pressures. The curve of Fig. 2 gives these figures based on normal assumptions for Lake ore practice. But in order to obtain the information that we really need we must go a step further and find the horsepower-hours per ton required with different rates of blowing in a given furnace.

By assuming that the results of the blast pressure chart given in the article on mechanical principles are correct, and combining its results with those just given we may obtain a very fair idea of the horsepower-hours required per ton of iron produced at different rates of blowing. Fig. 3 gives the results of such calculations for a 22.5 x 90-ft. furnace.

It will be seen that the total horsepower required for blowing rises very rapidly, and that the horsepower per ton of product rises at a rate almost exactly proportional to the rate of driving; at 350 tons per day 75 hp.-hr. per ton are required, and at 650 tons 150 hp.-hr. This increase of 75 hp.-hr. per ton represents a real loss.

even if the gas be worth nothing, for the fixed charges on the investment and the operating labor to burn it and utilize the resulting steam are important, however much or little the gas may be worth. Leaving a more extended discussion of these values to a later chapter, we may note that the sum of fixed charges and labor is seldom less than 0.25 cent per horsepower-hour, and therefore the difference in power cost at these two rates of driving is nearly 20 cents per ton.

It may well be reiterated that these are not absolute figures, and that they may vary considerably from the actual figures in a specific case, but that they are based throughout on assumptions in substantial agreement with facts, and it is believed they represent very well the relative power requirements under the given conditions.

Similar curves worked out for smaller furnaces show the same characteristics with so little difference, except in absolute values, that they need not be reproduced here.

The results will be shown in dealing with commercial considerations.

Effect on Flue Dust Loss

This is frequently the really controlling consideration as to the rate of driving in fine ore practice.

A. N. Diehl in presenting his paper "Data Pertaining to Gas Cleaning" (A. I. M. E., Trans. Vol. L, page 3), stated verbally as the result of careful investigation that the surface of the stock in a modern furnace was in a continual state of "teeter," particles rising in the gas current and falling back continually; under these conditions some of the finer particles must be regularly carried over by the gas, and we know they are. The lifting power of a current on an individual particle increases as the square of the velocity, hence the number of such particles which would be within the lifting power of a slightly increased gas current is very great, and as a result such an increase would quickly lead to a prohibitive flue dust loss; in other words, the difference in rate of driving between an insignificant and a prohibitive flue dust loss is a very small one, and the maximum permissible rate is found in this narrow range.

With the rapid progress being made in sintering flue dust it seems not impossible that our ideas on the subject of this limitation may experience a considerable change in the near future. The harmful effect of fine ore in the furnace has been explained earlier, and is coming more and more to be admitted, the uselessness if not absolute harmfulness of fine coke is well known; if we can transform these into a highly desirable furnace material without undue expense we may find that

the cheapest course is to blow out of the furnace an increased percentage of the objectionable fine materials, put them into a desirable condition and change them back again.

Where lumpy or plastic materials are used the flue dust loss is smaller in proportion to the smaller total quantity of fines present, and this is generally so small that flue dust ceases to be an important fact in the rate of driving under such conditions.

In actual practice we find by experience the rate of driving which suits the general conditions best, and that we regard as the normal which we desire to maintain.

Spontaneous Increase of Rate of Driving

There often arise conditions under which the maintenance of the best rate of driving is no longer possible. The furnace will sometimes start off and drive at a vastly increased rate without any change in the amount of blast having been made. For many years I did not know the reason for this phenomenon. It was first pointed out to me by A. J. Boynton of Lorain, that this condition arises from the fact that the rate of coke loss by solution or, more accurately, the percentage of the coke dissolved in the upper portion of the furnace, suddenly increases from some change in conditions, perhaps the distribution of the stock or a change in the tightness of the charge, producing a corresponding change in the equilibrium of CO and CO₂, with the result that more of the latter is formed at some zone, and this then dissolves more carbon from the coke in order to restore the equilibrium.

Another cause for such change, probably the most frequent one, is increased solubility of the coke due to a difference in oven practice, coal used, structure, or the like, or to a change in the fineness of the ore or its tendency to run down through the charge.

If a furnace working on hard ore were to change from a 10 per cent solution loss to the 22½ per cent solution loss which may occur with all fine ore, it would produce an increased rate in driving of about 15 per cent, and changes as great or even greater than this do at times occur.

The effect of such an automatic increase in driving is usually very objectionable for two reasons: First, it reduces proportionately the time permitted for the complete reduction of the ore; second, and much more important, it corresponds to a reduction of fuel in the hearth and a reduction of hearth heat available, exactly proportional to the increase in the rate of driving. Since, the quantity of blast being constant, the coke to satisfy it must be constant, and if each charge delivers less coke to the hearth proportionately more coke charges are consumed; that is, the rate of driving is increased.

As a result a furnace generally runs off cold in consequence of such a spell unless measures be taken to prevent it. The principal measures available are first, to increase the blast heat if possible so that it may make up the deficiency caused by the extra solution loss; second, to slow down the blowing engines so as to prevent the rapid driving even though the solution loss cannot be checked. If this does not result in reducing the driving to a rate proportional to the blast blown it is then necessary to reduce the burden to make up for the hearth heat lost. As a general thing a reduction in the rate of driving is usually accompanied, temporarily at least, by increased heat in the hearth due, presumably, to the more complete preparation of the stock before its entrance therein, and slowing down the blowing engines is, therefore, the proper procedure if the abnormal rate of driving be long continued.

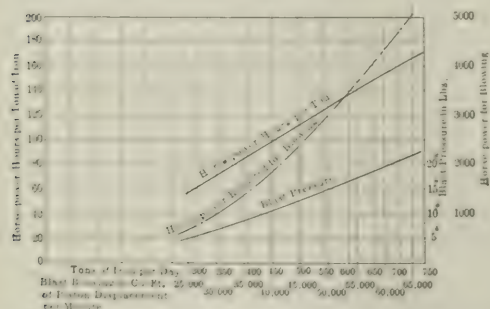


FIG. 3. BLAST PRESSURE, BLOWING POWER AND HORSEPOWER PER TON REQUIRED AT DIFFERENT RATES OF PRODUCTION WITH A FURNACE 22.5 X 90 FEET

Reduced Driving Caused by Furnace Becoming "Too Hot"

We sometimes encounter a phenomenon the exact opposite of that last described. The furnace becomes very hot, the silicon in the iron rises, the actual temperature of the slag and iron rise visibly, and presently the furnace slows down, "won't take the wind," the blast pressure rises decidedly, the rate of driving falls off, and presently the furnace begins to hang and refuses to settle without slacking the blast.

We do not know absolutely the cause of this condition, but as the exact opposite is caused by a sudden increase in solution loss, it is reasonable to suppose that this is caused by a sudden diminution of solution loss bringing an excess of carbon into the hearth.

This would cause the rate of driving to be slowed down in proportion to the increase in carbon delivered to the tuyere zone per unit of time. Increased hearth heat would be developed in the same proportion, part of this would expend itself in reducing more silicon, and the rest would pass out the top of the bosh and carry the pasty zone to a greater height, thereby causing the pressure to rise, and this co-operating with the greater depth of pasty zone would cause a decided increase in the lifting action on the charge column with sticking and hanging as necessary consequences. These are so exactly the results which we see in practice under these conditions that it seems safe to assume that the cause suggested is the true one.

A further confirmation is to be found in the serious after-effect of these conditions which is only too likely to be the scaffolding of the furnace, which is what we should expect from the rise of the pasty zone due to the excess of hearth heat.

After this was written I obtained extraordinary confirmation of its correctness from a chart of pressures at different heights during a "hot stick" furnished me through the kindness of Mr. John N. Reese and his assistant, R. C. Wallace, shown at Fig. 4.

It will be seen that the pressure drop in the bosh and that in shaft are about uniform, whereas in the zone just above the top of the bosh the pressure drop is 6 lb. in 9 ft. where it should be about $1\frac{1}{2}$ lb., so accounting for nearly all the excess pressure in the exact location where we should expect the abnormal sticky zone to be. It is interesting to note that this occurs in the straight section at the top of the bosh; if this were

absent and the upwardly covering shaft started directly on top of the bosh it is easy to believe that the sticking would be much worse.

Granting that the cause of this action has been found, what is the remedy? Obviously it is to dissipate the excess heat before it can carry the pasty zone much above the normal level and so prevent the formation at that level of a scaffold due to the adherence of chilled pasty material to the walls when normal temperatures are restored.

This can best be done by "following up" with more blast if the power is at hand to deliver it, for the same reason that we slow down when the furnace is running away. This tends to dissipate the excess heat, or rather to give it less time for action and also to keep the charge in rapid motion and so prevent scaffolding. Unfortunately, the high pressure which accompanies this condition not infrequently limits the quality of wind which can be delivered at the very time we need it most.

In such a case we have no recourse but to cool the furnace off by lowering the temperature of blast to the point required to restore normal conditions. Of course, if the furnace shows a tendency to continue these conditions indefinitely the remedy is an easy and agreeable one, we simply add enough more burden to take care of the excess hearth heat and restore the normal blast temperature, but at the beginning of such a condition a change cannot be brought through quickly enough to prevent bad consequences, so the other remedies must be applied first in any event, for they reach the seat of the trouble instantly.

The Effect on Life of Lining

It was at one time believed that any rate of driving in excess of a very moderate figure must necessarily result in reducing the length of life of the lining and increasing almost prohibitively the expense and loss of time for relining.

We know now that this is not generally true and that where practice has been good the greatest tonnage per lining is made on steady and uniform but fairly rapid driving.

As a matter of fact, rate of driving is only one, and by no means the most important factor in the life of lining.

The really controlling feature in life of linings is stock distribution. If that be correct we shall be able to drive faster and still have the lining last many times longer than it does with poor distribution; channelling due to the concentration of the lumps on one side of the furnace has destroyed countless linings in a few weeks, but even when this is absent there are frequently conditions due to distribution which destroy a lining quickly. In the next article I shall describe a case in my own experience in which a change of distribution gave a life of lining three times as long as before.

Slow driving may be almost as destructive of linings as excessive driving, for the movement of the charge becomes so slow that the whole of the furnaces is not kept in action, a portion of the charge ceases to descend and by long contact adheres to the wall and a scaffold is formed; this causes irregular work and channelling which quickly cuts the lining out, or else the scaffold eventually falls off and brings a quantity of brick with it, this starts a failure of the lining and its end soon comes.

There are other conditions than wear which destroy linings; they disintegrate behind the glazed face which forms on the bricks sometimes in a comparatively short period, three or four years or even less. A lining is just as effectively destroyed by this action as if worn

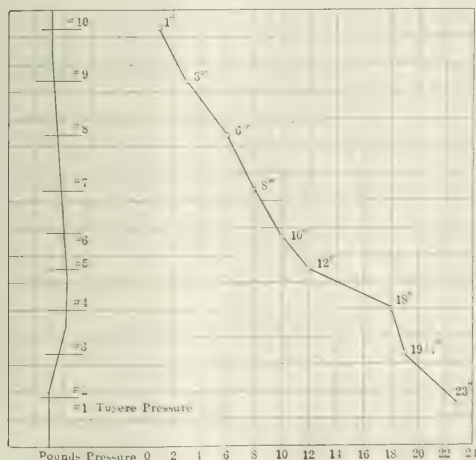


FIG. 4—CURVE OF PRESSURE DROP

out, and therefore might better have been worn out so as to obtain maximum production from it.

Speaking broadly then, we may say that while the rate of driving is one factor in the life of linings, it is such a small one, with proper conditions in other respects, that we may disregard lining cost in determining the best rate of driving.

From all that has been said as to changes in the height of the pasty zone, the danger of scaffolding they cause, etc., we may see some of the reasons for one of the best established facts of practice, that the best work can only be done over a long period by determining the best rate of driving and adhering to it rigidly except when corrective measures are needed temporarily. The furnaces which have in the long run made the best showing technically and have made the most money for their owners are run on that principle.

The Metallurgy of the Rarer Metals*

BY JOSEPH W. RICHARDS

There are many metals which may be called "the rarer metals." Among them the most interesting by far, to the metallurgist and to the economist, are those metals whose compounds are relatively cheap but which command a high price because of the difficulty of their reduction. These are the metals whose market price may at some time be reduced one-half, three-quarters, perhaps nine-tenths, by improved methods of reduction, and the discussion of how this might be accomplished and to what uses these metals at such low prices might be put, is interesting to the border of fascination.

If this article were being written thirty years ago, aluminium would be one of the metals to be discussed. It is now out of that class, but in 1886 it was one of the rarer metals, selling at \$10 per pound, although its ores were "as common as dirt." At that time you could buy a ton of bauxite ore containing 6/10 ton of alumina or 3/10 ton of aluminium, for \$5, while the 3/10 ton of aluminium was being sold for \$3,000, at wholesale. Or, eliminating the purely chemical work, 6/10 ton of chemically purified alumina could then have been bought for \$50, while the aluminium it contained was worth on the market sixty times that amount. Such were the metallurgical conditions in the aluminium industry thirty years ago, and so attractive were they to experimenters and inventors that the genius of the profession expended its best talents on the problem, with the result, in less than ten years, of reducing the market price to less than one-tenth its former figure.

The silicon industry furnishes another example in point. Silica is the most abundant and cheapest material in nature, yet silicon was selling in 1900 as a chemical curiosity at over \$100 an ounce. Imagine the stirring up which my metallurgical wits received, when in 1902, Mr. Tone, at Niagara Falls, showed me a barrel full, 100 lb. perhaps, of silicon made in his electric furnace, and asked me what uses it could be put to. At the present time, 10 cents per pound is a good market price for silicon, which is often sold by the carload.

It is such seeming fairy tales as these which constitute the fascination of those metals which are abundant in nature but whose high cost rests on the difficult and costly methods of reduction employed. Such opportunities exist, for our rising generation of chemists and metallurgists to make themselves famous and, incidentally, rich—but they will find their fame more of a reward than their riches.

Among the metals at present of high price, but which by improved metallurgical processes might be made very

cheaply, are beryllium, boron, magnesium, calcium, strontium, zirconium, molybdenum, barium, titanium, chromium and cerium (mixed metals of the cerium group).

Beryllium

Commencing with one of the light, alkaline-earth metals, its ore is not as rare as is ordinarily supposed. Most non-mineralogists link it with beryl, and think of the latter as a very pretty and very expensive gem—the emerald. But the emerald is only the clear green or aquamarine stone, while massive beryl, looking like massive green quartz, is much more common, and is even abundant in some localities. The beryl crystals of Acworth, N. H., are sometimes as large as a barrel, and the massive beryl at this locality is quarried like feldspar. Its composition is

SiO ₂	67.0 per cent
Al ₂ O ₃	19.0 per cent
BeO	14.0 per cent

It is difficult to say what the price of this material would be if it was desired by the ton, but it should not be expensive. When chemically treated, both the Al₂O₃ and the BeO which it contains could be separately obtained.

Up to the present, no one has succeeded in isolating the metal except by reducing a halide salt of beryllium by potassium or sodium (Bussy, Wöhler, Debray, Menier, Reynolds, Nilson and Petterson, Kruss and Morah) or by electrolysis of double chloride, bromide, or fluoride of beryllium and sodium or ammonium (Borchers, Warren, Lebeau, Liebmann).

These methods are tedious and costly for two reasons: first, they require the conversion of the beryllium into an anhydrous halide salt, which is a difficult chemical operation, and, second, the electrolysis sets free the halogen, which is very destructive of electrodes and apparatus. It is not to be expected that beryllium can be made cheaply until someone masters the direct electrolysis of the oxide, dissolved or suspended in a more stable melted salt. This is by no means an impossibility; a similar solution was found for the aluminium problem, and systematic, determined search would in all probability find the answer for beryllium. In such a case, the cost of the metal would depend only on the cost of beryllium oxide, being probably not more than 20 cents per pound plus the cost of the oxide. Since BeO is only 36 per cent Be, it would require 3 lb. of oxide to give one of metal; if the oxide cost 10 cents per pound, the total cost of the metal should not exceed 50 cents, by such a supposition process. Dealers in rare chemicals will charge you, at present, \$300 per ounce for a specimen of it.

Lebeau has produced beryllium bronzes by reducing directly, in the electric furnace, a mixture of beryllium oxide, copper oxide and carbon; 0.5 per cent of beryllium makes copper hard and sonorous; 1.5 per cent makes it yellow, and 5 per cent makes a fine golden yellow bronze.

Beryllium, like any other rare metal must find uses which justify its cost. Being white, malleable and unchanged in air, its specific gravity, 1.64, would make it particularly useful for objects where great lightness and permanence in air is the first consideration and cost secondary. So far we practically know nothing about its tensile strength or rigidity, about how it might be strengthened or stiffened by small additions of magnesium or aluminium or even of zinc, or copper, or manganese, or some other metal. We do not yet know the mechanical properties of its fine bronzes, except that they are somewhat similar to aluminium bronze, but in what respects they might be superior or perhaps unique is unknown. Finally the metal may

*A paper read at the Cleveland meeting of the American Institute of Chemical Engineers on June 14, 1916.

easily possess special properties, now unknown, which may render it particularly useful for some specific purpose. Its specific heat, for instance, is the highest of any useful metal, and its latent heat of fusion must be abnormally high, possibly 300 calories, and its latent heat of vaporization probably higher than that of any known element except carbon or boron. Such characteristics might give it special uses in electrical instruments, or for physical apparatus, where its cost would not exclude its use. Altogether, beryllium is a metal which will well repay extended metallurgical research and minute physical and chemical study of its many unique properties.

Magnesium

The metallurgist has been coquetting with magnesium for half a century, and has, as yet, not made a fraction of the progress which he should have made. We can get its oxide cheaply and in abundance, its salts are not very difficult to prepare, we know their properties to a considerable extent, we know almost all the properties of the metal which bear on its isolation, and yet the industry lags and halts as if there were no such thing as modern metallurgy. To prepare by tedious methods the anhydrous double chloride, and then to electrolyze it about as Matthiessen did fifty years ago, is nearly all that can be said with certainty about its present metallurgy. At any rate, using magnesium oxide costing a few cents per pound, the metal sells for about as many dollars per pound, and yet there is a great scarcity of the metal.

Dr. W. M. Grosvenor, in a recent paper before the American Electrochemical Society, summarizes the present methods of production and the uses of the metal. Happily he also suggests the great field open for improvement, especially for radically new metallurgical methods of production. With magnesium in its salts costing less than 8 cents per pound, he places the actual cost of the metal at \$1 per pound, leaving over 90 cents per pound for the cost of its extraction. "Brethren, these things ought not so to be." Speaking with the enthusiasm born of past achievements in electrometallurgy, along entirely analogous lines, a modern, up-to-date attack on this problem ought to result in producing magnesium at 25 cents per pound.

The point of attack should be undoubtedly to reduce the oxide directly. The halogen salts are hygroscopic, and the halogen is destructive of the reducing apparatus. It is almost certain that proper research will enable the electrometallurgist to feed MgO directly into an electrolytic bath of fused salts and take magnesium or magnesium alloy from it. The pure metal will float on almost any fused salt, but its alloy with heavier metals may be made such as to sink, and many of its alloys have immediate useful applications.

Dr. Grosvenor makes suggestive remarks about the reduction of magnesia by carbon. If the boiling point is only 1200 deg. C., then a process of reduction similar to that of zinc oxide might be practicable if we could (1) find a retort material which will stand the temperature required (1800 deg. to 2000 deg. C.), and (2) condense the vapors without contact with air. Fortunately, magnesium does not form carbide at high temperatures, so that its reduction is simpler by that much. Dr. Grosvenor speaks of a chemical process which will use cheap raw material, a moderate amount of fuel, and give a fair efficiency of reduction. With all expenses added, he estimates a cost not over 35 cents per pound. This may be true, but whether it materializes or not, he and his colleagues have the right vision of the possibilities, I may even call them the probabilities, of this field; they are truly "absolutely fascinating."

While the world-war lasts, with its enormous demand

for magnesium for military purposes, the price will remain in the dollars per pound. But experience in this line is being rapidly accumulated, and improvements are undoubtedly rapidly succeeding each other, although keen competition is keeping them secret as far as possible. After the war's close, with normal industrial conditions reappearing, magnesium will undoubtedly sell at a price which will take it out of the class of the rarer metals and put it among the common ones. As the price goes down its industrial uses will increase in a geometric proportion, and instead of production being expressed in thousands of pounds per year it will reach thousands of tons. This will be another of the by-products of the great war's stimulus to metallurgical industry.

The possibilities held out to the metal industry by reasonably cheap magnesium are extremely interesting. The stiffening of magnesium to produce strong alloys with specific gravity not over 2 has not been properly studied. It is quite possible that alloys analogous to *duralumin* may be discovered, as strong as soft steel and only 30 per cent of its weight, which will find extensive use in aeroplanes and dirigibles. Such alloys may also largely displace aluminium alloys, which are used by thousands of tons annually in the automobile industry, with a saving of one-third in weight, which will compensate for a higher first cost. The metallurgical uses of magnesium will also be greatly extended by its lower price, such as for deoxidizing brass, bronze, nickel, monel metal, since it is a much stronger deoxidizer than aluminium. In fact, aluminium has blazed the way into numerous uses for which magnesium, as soon as it becomes cheaper, will compete and replace its older sister. With supplies of magnesium ore as plentiful as those of aluminium ore, and the metallurgist awake to his responsibilities and producing the metal cheaply, there will inevitably be a large future for magnesium as one of the common metals of every-day life.

Calcium, Strontium, Barium

These are a trio of highly interesting elements, common enough in nature, but all scarce and of high price because of the metallurgist's lack of efficient and cheap methods of reduction. With burnt lime, CaO, one of the cheapest of common materials, strontium sulphate, a mineral found in considerable abundance, and barium sulphate, so common, as heavy-spar, that it is used as an adulterant for some cheap paints, the metallurgist is again faced with the demand for cheap methods of reduction. And yet, although calcium is sold at a few dollars a pound, strontium and barium cost several dollars per ounce. Here is a twofold need: first, cheap production; second, a thorough study of these metals to find out their specific properties and their particular uses. Which should be undertaken first is an interesting topic for discussion. Historically, the metallurgist has usually produced the metal first and then studied its properties and possibilities; at present, with these metals already at hand, metallurgical activity might be greatly stimulated by extensive studies of the properties, alloys, and chemical uses of these elements. Our present information in this direction is fragmentary and partly unreliable as far as it goes. A Carnegie Research scholar, or even the Bureau of Standards, by disclosing to us some of the unknown properties of these elements, might stimulate the experimenter to renewed efforts to find cheaper methods of reduction.

Calcium, at the present time, is the best known of these three elements. The method of electrolyzing its fused chloride and lifting the metal away from the surface, as an irregular stick, has been fairly successful, and since the chloride is not difficult to dehydrate, the whole operation is not very expensive. Calcium is there-

fore, at present, perhaps a semi-rare metal, which could be produced much cheaper even by present methods if made on a large scale to fill a large demand. The method of production is easily susceptible of minor improvements, and the chlorine is a valuable by-product to the manufacture. The principal hitch at present is in finding the uses for a large production of calcium. Here is where extensive study of the properties and possible uses of calcium would greatly stimulate the metallurgical industry. With specific gravity of 1.85, its possible alloys with other light metals should be exhaustively studied; quite possibly some of them are strong, resistant to air and water, perhaps even to acids. Calcium tarnishes easily in the air, and magnesium also, but it is quite possible that some alloy of the two does not tarnish, and may have valuable mechanical properties. Another large possible use is as a chemical purifying agent in melting and casting metals. Calcium-silicon-aluminum alloy has already found application as a deoxidizing agent in steel, because while aluminum oxide and silicon oxide and their combination with each other are infusible at steel-melting temperature, and therefore are eliminated slowly from the metal, calcium oxide forms with these an easily fusible slag, which easily rises out of the molten metal. It is quite possible that a small addition of metallic calcium may in a similar manner reduce the amount of sulphur and phosphorus in steel, because it is either as calcium sulphide or calcium phosphate that these elements are eliminated in refining steel. Other metals and alloys whose properties are damaged by sulphur or phosphorus may be similarly refined or improved. The alloys of calcium with copper, tin, bronze, brass, monel metal, and other commercial alloys have not been studied; until they are, no one knows how many useful mixtures may exist with particular properties of industrial value. The question of adding calcium to the light stiff aluminium alloys, for instance, is worthy of attention, but has not been touched.

Strontium is a silvery-white, very soft metal, with properties similar to calcium, density 2.54. Its ores cannot be called rare minerals, and it is a rare metal, therefore, only because of the difficulty of its isolation. It is chemically very active, and electrochemically extremely hard to manage. It has about the same specific gravity as its fused salts, so that it neither rises nor sinks in any of them quickly; it seems also to redissolve in its melted salts with great velocity, so that very high current density is required to obtain any metal at all. Its surface tension appears to be abnormally high, so that it separates out in more or less minute globules which are highly indisposed to running together into one mass. What an attractive subject this forms to the electrochemist who really wants to meet difficulties and taste the joys of overcoming them. And then one may well ask: To what purpose? Here, again, we do not know, but we can feel confident that in the innumerable list of possible combinations of metals strontium might have properties different from any other element, which would lead to its employment on a large scale. These are all questions of the future which form the undiscovered country open to the investigator and chemical pioneer. We may well thank our stars that the world of science still holds unexplored areas to tempt the adventurous investigator and to reward the *Wanderlust* of the metallurgical pioneer.

Barium is common in its compounds and almost unknown in itself. Under electrolytic conditions where calcium comes out *en masse*, and strontium separates as small globules, barium is obtained only as a fine powder. Its density is 3.75, but its salts are heavier than the corresponding strontium and calcium salts, so that the

fine powder may sink or swim, largely according to the temperature. And yet the fused barium salts are very decent and manageable salts, easily obtained anhydrous and melting cleanly. Their electrolysis, however, is nearly the most difficult task that the electrometallurgist can take up. But it should be taken up and mastered, because a metal so common in its compounds could be obtained in large quantities if uses for it were developed, and if our modern electrometallurgists are worthy successors of Faraday, Bunsen and Castner, they should vigorously attack the problem of its cheap extraction. Even if their end was not reached, they would be whetting their metallurgical wits upon the finest of chemical whetstones, and their experiences would be of value to themselves as well as to other lines of electrometallurgy.

Boron

As an intermediate element, semi-metal, cheap and abundant in its compounds, yet almost unknown as an element, boron is very interesting. Although quoted at several dollars an ounce, yet there are possibilities of it being made for x cents per pound, where x may be anything over 25. It is only the prophetic prescience of the enthusiastic metallurgist, however, that can discern this goal in the distant future.

Boron occurs in nature as its oxide, sassolite, containing 31 per cent of boron; as borax, containing 11.5 per cent of boron, and as colemanite, containing 18.9 per cent of the metal. These sources are comparatively abundant, the oxide being found in volcanic districts, borax near dried-up lakes, and colemanite (calcium borate) being literally a waste product of the borax mining for which no use has yet developed.

Gay-Lussac and Thenard, Wöhler and Sainte-Claire Deville reduced the oxide by potassium or sodium, other chemists by phosphorus, magnesium, aluminium and calcium, while Duncan reduced boron chloride gas by hydrogen. Chemically, its reduction does not appear to be of extraordinary difficulty. Electrochemically, Davy electrolyzed fused boracic acid, Gores potassium borofluoride, and Faraday fused borax. All describe having isolated boron. Quite recently, Weintraub has decomposed boron chloride by hydrogen in a high-tension arc, and obtained purer boron and in larger quantity than any previous investigator. His classical paper is in the *Transactions of the American Electrochemical Society* (1909) 16, 165.

The properties of the pure boron obtained by Dr. Weintraub are exceedingly interesting. Its fusing point is extremely high, between 2000 deg. and 2500 deg. C.; it was fused in a boron nitride crucible under the pressure of its own vapor. Its boiling point is near to its fusing point; it has considerable vapor tension as low as 1600 deg. C. It has a conchoidal fracture, and is nearly as hard as the diamond. At room temperature it is electrically almost a non-conductor, but at 500 deg. C. its conductivity has increased 2,000,000 times; at 1000 deg. C. its conductivity is of the order of that of the metals. Applying moderate voltages to a cold piece, it soon warms up and makes itself a good conductor. Such extraordinary properties suggest its use for many interesting electrical contrivances, which are enumerated by Dr. Weintraub.

Other uses of boron, which have not yet been thoroughly investigated, are in the formation of boron steels and boronized copper. The former were investigated by Guillet, in France, with irregular results; in some respects, at times, the effects were similar to that of vanadium in the famous vanadium steels, at other times the results were different. The uncertainty may have been due to irregular composition of the ferro-boron alloy used. A great amount of investigation should be

done on this line, first in making a reliable quality of ferro-boron, and second in using it systematically in various qualities of steel. The question of boronized copper is in a still greater state of uncertainty. Boron or even boron sub-oxide (B_2O_3 or, perhaps, boron saturated with B_2O_3) added to melted copper enables a perfect copper casting to be obtained of practically 100 per cent electrical conductivity; a trade product sold as boronized copper has similar effects in producing sound copper castings. These results are only the beginning of an extensive field of investigation of the effects of small amounts of boron on metals and metallic alloys. They will certainly lead to important metallurgical discoveries and improvements.

In metals and alloys boron can act chemically as a purifying or refining agent to remove oxygen, nitrogen, and perhaps sulphur, phosphorus, and dissolved oxides, while in larger amount it acts metallurgically as an alloying element. In the latter respect it forms true alloys, such as the ferro-boron alloy, which is an article of commerce. The possibilities of extensive use in molten metals and alloys are great, but mainly dependent upon systematic metallurgical research in properly equipped laboratories.

The production of the metal and its alloys also needs expert attention. For use in steel, a good uniform quality of ferro-boron is needed, and the manufacture of this in satisfactory uniform quality has not yet been mastered. Some years ago, the Pacific Coast Borax Company offered a prize of \$500, to be awarded by the American Electrochemical Society, for a practical electric furnace method of producing ferro-boron directly from calcium borate (colemanite), a waste product of the borax mines. A few years later the prize money was returned by the society to the company as not having been earned, although several attempts were made at it. For use in copper, brass and bronze, a cupro-boron alloy answers as well as having pure boron. One method of making this is being tried, and the product is giving some very satisfactory results. Improved and more certain means of getting boron into copper are needed, and could probably be found by a moderate amount of careful investigation. As for pure boron, and the fascinating possibilities dependent on its remarkable properties, Dr. Weintraub's method makes the product, but at considerable expense, and a cheaper, easier method is a great desideratum. If such is found, boron will certainly occupy an important place among the useful metals.

Chromium

This element is also common and abundant in nature, and rare and expensive as a metal. Chromite, containing 34 per cent of chromium, costs normally \$20 to \$25 per ton, while the ferro-chromium alloy produced from it sells at \$100 to \$550 per ton, according to the per cent of chromium and carbon contained. But pure chromium, carbon-free, is produced only by reduction of chromium oxide by aluminium, and commands 75 cents per pound. The use of chromium in steel is rapidly extending to all varieties of extra hard and high-speed steel, but the use of pure chromium is limited by the high cost of its production and our lack of knowledge of how to handle it and of its possible useful effects. For example, chromium electroplating is white and durable, and for many purposes may be superior to nickel and almost equal to platinum plating, but the technique of always getting perfect plating has not been satisfactorily mastered. Cobalt-chromium alloys have been made which have some of the remarkable properties and uses of high-speed tool steel (stellite alloy of Mr. Haines). This is an excellent example of totally unexpected and valuable physical properties being discovered

by systematic investigation. These alloys, however, must be made from pure chromium and not from ferro-alloy. How many other remarkable alloys yet remain to be discovered by patient and intelligent investigation no one knows or can even guess.

As for the methods of reduction, ferro-chromium alloy carrying high carbon (6-8 per cent) is produced quite cheaply in crucibles, cupola furnaces, blast furnaces, or electric furnaces. Low-carbon ferro-chromium commands three to five times as high a price, because of the difficulty of decarbonizing the raw product. It is very much to be hoped that tests will be made in the electric shaft furnace to see if it is not possible to produce directly from the ore a low-carbon product. The thing has been done in the case of pig iron, producing a low-carbon product which is called pig steel; there is no inherent impossibility in similarly mastering the conditions for producing directly the low-carbon ferro-chromium. The present prices of the two products, \$100 and \$500 per ton respectively, would warrant great efforts in that direction.

Similarly, chromium is not a difficult metal to reduce to the metallic state, but it is a difficult question to find the proper flux and to keep carbon out of it. Goldschmidt reduces it by aluminium; electrolysis of its fused salts is difficult because of their high melting points. If electrolysis of aqueous solutions of chromium salts could be satisfactorily controlled, so as to produce heavy deposits, this might open the door at once to cheap and pure chromium. Electrolysis of molten relatively fixed salts in which chromium oxides are dissolved (similar to the Hall aluminium bath) is not a hopeless proposition. The chromium would be plated solid, however, on chromium cathodes, since the working temperature would be below the melting point of chromium.

The metallurgy of chromium is full of attractive possibilities, and the usefulness of pure chromium in the field of alloys is only beginning to be scratched; the scratching, however, is proving very much "worth while."

Titanium

Our friend Mr. A. J. Rossi and the Titanium Alloys Manufacturing Company of Niagara Falls are the *alpha* and *omega* of the titanium industry. Nearly fifteen years ago my first introduction to Mr. Rossi was in the historic barn at Niagara, the cradle of so many of the Niagara Falls industries. Mr. Rossi was running the electric furnace and Mrs. Rossi was in the little laboratory making the necessary analyses.

Everyone knows of the enormous masses of titanic iron ore in northern New York and Canada, which contains so much iron and so little sulphur and phosphorus, that every blast furnace would be glad to get it if it was not for the titanic oxide, which makes it so unworkable that you could not give it away to them. Mr. Rossi tried first to extract the iron only, throwing away the titanium in the slag, but that was not profitable. He then turned to producing ferro-titanium alloy for use in steel and cast iron, and by indomitable perseverance has made that a success. A finely written booklet of over 100 pages, published by his company and to be had for the asking, tells the whole story, so why take up time to rehearse it here? Get the booklet and read it.

In addition to titanium treatment of steel, to deoxidize and denitrogenize, this company also makes a specialty of titanium-treated aluminium bronze, also of titanium-treated bronzes and brasses of various compositions.

With titanic iron ore carrying 10 to 15 per cent of titanium as cheap as iron ore, and if iron-free material is required, rutile, 60 per cent titanium, at 5 to 7 cents per pound, there is no lack of cheap raw material. If

uses are found for pure titanium, however, some other than the electric furnace must be used to reduce it, because, in absence of iron, titanium carbide would result. The methods for producing pure titanium are, like its prospective uses, still in the future, but they nevertheless are worth study and work. One can buy titanium metal now at about the price of silver, but if the problem were properly faced it could probably be made as cheaply as chromium.

Molybdenum

Molybdenum sulphide, MoS_2 , 60 per cent molybdenum, looks almost exactly like graphite, and is about as widely distributed. Normally, it can be purchased as 90 per cent concentrates at 25 cents per pound. This would make the raw material for 1 lb. of molybdenum cost nearly 50 cents; the selling price of the metal is about \$2. This leaves a large margin to pay for reduction. In fact, \$1 per pound of contained molybdenum ought to return the reduction works a good profit.

However, the principal need of the molybdenum industry is a better utilization of its sources of raw material. The deposits have not been, in general, properly prospected or opened up, and then not properly worked. They are usually low-grade propositions, with 5 to 10 per cent of molybdenite disseminated through hard rock. This calls for careful study of crushing and concentrating methods, so as to minimize waste and loss. In most cases, the actual treatment falls far short of this, and possibly half the molybdenite in the ore is lost. The producers of the concentrates are being paid high prices for their material, but the market is limited and dull. If molybdenite were sold cheaper, there is little doubt that ferro-molybdenum, 50 to 85 per cent molybdenum, could be sold at half its present price, and the uses of molybdenum in steel correspondingly increased. New uses have also been found, such as the molybdenum wire so useful in electric resistance furnaces. This wire is scientifically very useful in that it resists the alloying action of many liquid metals even at very high temperatures. Dr. C. G. Fink of the Edison Lamp Works has studied these notable physical and chemical properties, and has described them in the *Transactions of the American Electrochemical Society* (Vol. XVII, page 229, 1910).

Zirconium

We may mention this element, which, as metal, is rare enough, but whose oxide has recently been found in considerable abundance. The familiar mineral zircon is the silicate, containing nearly 50 per cent of zirconium, but it is found only in limited amount. In the last ten years the oxide, baddeleyite, has been found in large quantities in Minas Geraes, Brazil, running 75 to 95 per cent pure, giving 50 to 75 per cent of the metal. This source is now so common that it sells at 4 to 5 cents per pound, and is being used in large quantities as a refractory material, on account of its high melting point (2000 deg. C.), high resistance to all kinds of slags, low thermal conductivity and low coefficient of expansion.

The metal, however, is almost an unknown quantity. It has been obtained by the action of potassium or sodium on the anhydrous fluorides. Fused, it is white, density 6.4, melting point 1500 deg. C., hard enough to scratch quartz. Ferro-zirconium has been made in the electric furnace and used in small amounts in steel with rather indefinite results. And yet, if some very useful proportions of zirconium were discovered, the metal could undoubtedly be prepared at a reasonable price—only a fraction of the \$5 per ounce now asked for it as a chemical curiosity. How it is to be obtained cheaply

is one more of the interesting questions confronting the metallurgical pioneer.

Cerium

There is a peculiar interest attaching to this metal and its close associates, from the fact that hundreds of tons of fairly rich cerium material is lying on the waste heaps outside of the incandescent mantle factories. The thorium ore used by these factories is monazite—a phosphate of the cerium earths plus thorium silicate. On extracting the thorium, the residue is worthless for mantle fabrication. It is known as "commercial cerium carbonate," and contains cerium, lanthanum, neodymium, praeosodymium, samarium, gadolinium, yttrium, ytterbium, a little thorium, and considerable alkalies, iron, phosphoric acid and silica. By treatment with acids, precipitation of the rare earths, and ignition, a chocolate-brown mixture of oxides of the rare earths is obtained, in which cerium oxide predominates, and which contains nearly 50 per cent of metallic cerium. When this mixture is reduced directly, without further separation, to the metallic state, an alloy of the rare earth metals is obtained which is known as mixed metal (mischmetal) or impure or commercial cerium. The composition of mischmetal naturally varies, but may be taken as approximately 30 to 50 per cent of cerium, 15 to 25 per cent of lanthanum, 10 to 15 per cent of the didymiums, up to 20 per cent of the yttrium metals, and 1 to 5 per cent of thorium.

An immense amount of laboratory and practical work has been expended on the production of mixed metal and of purer cerium. Professor Muthmann and his students in Munich and Alcan Hirsch in the United States deserve particular mention for their articles, in *Liebig's Annalen* (1902 to 1910) and *Transactions American Electrochemical Society* (1911) 20, pp. 1-102, respectively. Dr. Auer von Welsbach was the pioneer in the commercial manufacture and use of mischmetal. Annoyed by the sight of heaps of the cerium residues around his mantle factories, he experimented with their reduction to mischmetal and with the possible uses of the latter. Finding that it gave off sparks when scratched he conceived the idea of using it in automatic lighters, but found that it sparked far too feebly and unreliably to be practical. He then thought that if he purified the cerium it might give sparks more freely, but on making the purest cerium he found it to spark less than the impure metal. Turning in the opposite direction, he took mischmetal and added to it alloying metals not of the rare earth class, and found that they increased the sparking property. Iron, for instance, when increased to 30 per cent gave an alloy with remarkable spark-giving properties, such as make it most efficient and reliable in automatic lighters. This has formed the basis of the 'pyrophoric alloy' industry, since although other metals have similar effects the 30 per cent iron alloy is probably the best sparking alloy, for general use, so far made.

The electrolysis of fused cerium salts, double chlorides or double fluorides, to give the melted mixed metal is carried on on a large scale in Austria at Treibach, in Germany near Berlin, and was commenced in the United States, in 1916, near New York City, by Mr. Hirsch and his associates. The technique is not easy to master, and all the works keep their operations as secret as possible. The principal difficulties are the resolution of deposited metal, metal fog, and scattering of the metal as fine globules or 'metal-mush' through the electrolyte, making it difficult to unite the metal to one melted mass. Since the latter trouble is largely due to surface tension, a study of this property, particularly how it can be diminished, might help in overcoming the difficulty. As an example of the opposite effect, the

cupelling of lead on a bone-ash muffle depends absolutely, for its success, on the surface tension of the molten lead. But, metallic tellurium, in quite small percentage, *decreases* the surface tension of the lead so greatly that the metal *wets* the cupel and cupellation is rendered impossible. Arsenic, on the other hand, *increases*, the surface tension of melted lead, and is therefore purposely added to it, about 0.25 per cent of it, to lead being made into lead shot, in order to make rounder shot.

A physical investigation of such effects on cerium might well assist in overcoming the scattering of the metal in globules in the electrolyte. Another direction in which improvement might be made would be the careful study of the eutectics of mixtures of cerium salts with barium salts, so as to find an electrolyte of lower melting point in which the losses by re-solution of deposited metal would be less than they are at present. Another possible improvement would be the finding of an electrolyte which would dissolve cerium oxide or the mixed oxides directly, and give metal by electrolysis. Such a bath has been discovered for aluminium oxide, and a long experimental search for a similar bath for the cerium oxides would be amply justified.

The possibility of using the 30 per cent iron alloy as a melted cathode, and enriching it in cerium by electrolysis, might be considered. If we had the fusing point curve of cerium-iron alloys we could draw some useful conclusions in this direction. The addition of small amounts of other metals to the bath, so as to produce other useful cerium alloys directly, might facilitate the electrolytic operation. Further experience with the process, particularly by those familiar with the electrolysis of molten baths for sodium, magnesium or aluminium, will very probably lead to considerable improvements and reductions of cost.

The uses of cerium and particularly of its alloys is sure to increase, and may attain considerable proportions. It has been proposed by Borchers as an addition in small quantity to aluminium, to improve its properties. But the large use will always be the pyrophoric alloys, which have so largely replaced matches. Before the European war, over 3000 workers were employed in Austria in this industry of pyrophoric alloys and automatic lighters. Mistakes were made in the early days of the industry, and some alloys put into lighters which crumbled to pieces by the time the apparatus reached Australia, but continual improvement was being made, until a satisfactory substitute for matches was attained. The improvement most needed in the pocket lighting apparatus is to be able to dispense with alcohol or similar liquid; a wick impregnated with a *solid* combustible which can be ignited by a pyrophoric alloy, would give a great impetus to this art.

The author apologizes for making this paper so largely critical and prophetic. If it has sounded too prospective in tone, the excuse must be that it is inherent in the subject. Some of these elements are among the most common in nature, yet they remain so rare in practical life that they are still chemical curiosities. But the chemical curiosities of one age have frequently become the chemical commonplaces of the next age, and even within a generation some of us have seen this happen, under our own eyes. Let us then be foresighted, forehanded, and anticipate possible developments a little by such a general review as has just been given, so that when some wonderful changes and improvements are made in the next few years we may have the satisfaction of knowing that we glimpsed their shadows some time before they arrived, and may even have assisted in hastening their arrival.

Refining Vegetable and Animal Oils*

BY CHARLES BASKERVILLE, PH.D., PHARM.

The terms "fat" and "wax" are commonly applied, more or less indiscriminately, to solid substances which have a greasy feeling to the touch and do not dissolve in water. Physically, waxes are regarded as having generally a harder consistency than fats. Chemically, fats are usually compounds of the trihydric alcohol, glycerol, $C_3H_5(OH)_3$; while the waxes are compounds of monohydric alcohols of large molecular weight; for example, cetyl alcohol, $C_{26}H_{54}OH$; myristic alcohol, $C_{14}H_{29}OH$, and cholesterol, $C_{27}H_{46}OH$. The names applied to some of these substances do not lessen the confusion; for example, "wool fat" and "spermaceti" are compounds of cholesterol and cetyl alcohol, hence are in reality waxes; while "Japan wax," a compound of glycerol, is actually a fat.

A fat, such as is indicated above, has among other physical properties a characteristic melting-point. Those which are liquid at ordinary temperatures are called *oils*. It is of such substances more especially that this communication deals with, although reference will be made to coconut oil, which may or may not be a solid at ordinary temperatures, therefore technically might be regarded as a fat.

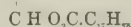
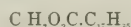
It will be understood that the term "oil" as here used, is not to be associated with the natural or petroleum oils, *i.e.*, hydro-carbon oils, or the essential oils, both classes of which in general exhibit in a way the physical but not the chemical properties, necessarily, referred to above.

Fats are widely distributed in the vegetable and animal kingdoms, and, referring to the former only for the time being, we may say they are primarily glycerides of oleic, palmitic and stearic acids. These fats are found *mainly*, but not necessarily, in the reproductive bodies, such as spores and seeds. They are found in spores, sexual and asexual, of many *algæ*. In angiosperms they are widely distributed, replacing, wholly or in part, carbohydrates as reserve food material, and they are often associated with protein reserves; for example, in the seed from which colza oil, palm oil, cotton-seed oil, linseed oil, olive oil and cocoa butter are obtained. It is present, perhaps, as a reserve food material, associated with starch, in some tubers. The starch in the parenchyma of the stem of certain plants may be converted into fat during the winter's cold, and *vice versa*, when there is a rise of temperature in the summer time. Without venturing into the misty etiology involved, we may, for our purposes realize the likelihood of the presence of carbohydrates, proteins and other substances derived therefrom, as gums, etc., in oils obtained from these sources by the various means to be referred to later.

These oil-containing bodies invariably contain some coloring matter. Some of the coloring matters appear to be essential for certain of the changes just referred to. The most prominent pigment appears to be chlorophyll, an ester of tricarboxylic acid, chlorophyllin, $C_{55}H_{72}N_4Mg(COOH)_3$, and is the normal green coloring matter of plants. It may easily be broken down into substances that contain magnesium and substances that do not contain that metal.

Accompanying the chlorophyll are several pigments more or less insoluble in the cell sap; namely, carotin, $(C_{40}H_{56})$, yellow to red in color, and xanthophyll $(C_{40}H_{56}O_2)$, a neutral body, yellow to orange in transmitted light. These substances may be destroyed by the action of such powerful chemical agents as concentrated sulphuric acid, especially if heated in the presence of oxygen.

Closely related to the fats is a group of substances known as phosphatides or lecithins. Occurring in egg-yolk to about 9 per cent, we find them to the extent of from 0.25 to 1.75 per cent in cereals and leguminous seeds, hence they appear in the oils extracted from the seed. They are glycerol esters, two of the acidities being neutralized by fatty acids, the third being saturated by a combination of phosphoric acid and choline, as shown here:



It is easily broken up by lipase, and hydrolized by boiling with alkalis and acids.

We always also find a small quantity of unsaponifiable residue in fats, which is in the main composed of the monohydric alcohols, cholesterol, $\text{C}_{27}\text{H}_{46}\text{OH}$, and phytosterol, the latter now being a generic term for a group of allied substances, with formulas varying from $\text{C}_{28}\text{H}_{48}\text{OH}$, (sitosterol) to $\text{C}_{30}\text{H}_{50}\text{OH}$ (stigmosterol). Cholesterol occurs in the bile, brain and blood of animals, and is the chief alcohol constituent of wool-fat. All vegetable fats contain phytosterol, the amount varying from 0.1 to 0.3 per cent, being even higher in the oil obtained from certain peas and beans, especially Calabar beans.

The oils are extracted by disintegration of the mass involving a disruption of the oil-sacs: (a) with a suitable solvent; (b) rendering by heat, with or without water; (c) or pressure, mechanical, applied when the mass is cold or hot.

If the mass extracted be selected and perfectly clean and fresh, the oil or fat obtained is usually neutral and "sweet." The exigencies of commercial operation do not admit of these conditions, however, so the oil or fat produced is usually acid and more or less contaminated. The contaminations may be quite normal and natural. They may be bacterial in nature and also contain the very interesting substances known as enzymes (lipase, for example) which induce hydrolysis; that is to say, they will cause any water present to disintegrate the fats (and other bodies) into simpler bodies. This may be facilitated by exposure to air and light, so that a freshly expressed oil that is sweet may soon acquire an unpleasant taste and odor. In some cases we say it becomes rancid, but in all cases the oil develops acidity, and the amount of the acidity of a particular oil is a function of time.

Under favorable conditions—and they are usually favorable—these changes take place within the oil-containing bodies, so that freshly produced oil is usually acid, which acidity increases on keeping. The enzymes are "killed," or decomposed, or at least their directive activity ceases when they have been exposed to a temperature of about 200 deg. C. It has not been considered a good procedure by the practitioners of the art of oil extraction and refining, however, to heat the oil to such a temperature immediately after its production; but I venture the opinion that the increased development of acidity in crude oil in storage or in transit to a refinery will be materially affected by such treatment. However, it will be necessary to be assured that substances charred or scorched at that temperature are absent.

As mentioned above, oils and fats are primarily glycerides of the saturated palmitic ($\text{C}_{16}\text{H}_{32}\text{O}_2$) and stearic ($\text{C}_{18}\text{H}_{36}\text{O}_2$) acids, associated with the fatty acids of several unsaturated series. For example:

1. Oleic acid, $\text{C}_{18}\text{H}_{34}\text{O}_2$, type $\text{C}_n\text{H}_{2n-2}\text{O}_2$.
2. Linoleic acid, $\text{C}_{18}\text{H}_{32}\text{O}_2$, type $\text{C}_n\text{H}_{2n-4}\text{O}_2$.

3. Linolenic acid, $\text{C}_{18}\text{H}_{30}\text{O}_2$, type $\text{C}_n\text{H}_{2n-6}\text{O}_2$.
4. Clupanodonic acid, $\text{C}_{18}\text{H}_{28}\text{O}_2$, type $\text{C}_n\text{H}_{2n-8}\text{O}_2$.
5. Ricinoleic acid, $\text{C}_{18}\text{H}_{34}\text{O}_3$, type $\text{C}_n\text{H}_{2n-2}\text{O}_3$.

The last is an hydroxy acid, which undergoes a particular polymerization under suitable conditions.

Most fatty oils, on exposure to the air, tend to thicken, due partly to oxidation and partly to polymerization, or both. Oils are, in fact, classified by many according to their drying qualities and tendency toward resinification. These properties play an important part in their utilization in the arts; and their treatment in refining is materially affected by the time which may have elapsed from actual production to their refining. For example, a freshly produced linseed oil may be profitably refined by a process which is inapplicable if the oil be "aged oil."

Oil, as stated, is normally a liquid, and we usually associate the phenomena of solution with a liquid. To be sure, this is a restricted conception, but will answer for our purposes. In this connection oil acts like water as a fluid. Water in motion carries fine particles suspended through long distances and deposits them in time, when fairly quiet, as we know from the formation of alluvial soils. Water carries certain substances in solution. These latter substances are sometimes colored and are partly fixed on the filter when that water passes through certain filtering media. For instance, we are able to adsorb Congo red from a water solution with filter-paper. Again, water carries certain substances which do not stop on the filter; they are invisible and show themselves only when we apply the ultra-microscope. These finely divided substances, not small enough to be in actual solution, will remain suspended in the water for long periods of time. They are called colloids. By various means, through heat, addition of an acid, an alkali, or a salt, by the influence of an electric current, or by the addition of other colloids, these very finely divided substances may be caused to agglomerate; that is, they may be converted into particles of sufficient size to be separated from the fluid by means of a filter. Exactly the same is true of oils. Organic colloid solutions may be viscous; the liquid particles are suspended in a liquid medium.

Many of the contaminating substances, referred to here in general, may be suspended in the oil, may be in solution in the oil, or may be in a colloidal condition in the oil.

It will, therefore, be quite apparent that crude vegetable and animal oils contain a variety of impurities traceable to a great variety of causes. The character of the crude oil depends not only upon the kind and part of the vegetable (wood, nut, seed, etc.) and animal (fish, whale, etc.) used, but the quality of the raw material at the time of expression or extraction (rusting, rotting, fermentation, sprouting, heating, etc.) the method followed, the care exercised in the process, and the conditions to which the oil is subjected prior to its refining. In many cases, in fact, we find metallic soaps present in the crude oil, which soaps have resulted from an interaction of decomposition products of the oil and the rendering vessels.

No universal method for refining animal and vegetable oils is known. Your forbearance will not be taxed, however, even were it profitable, in discussing all the various proposals for fitting these oils best to the several purposes experience and practice have shown them to be applicable. A number of processes have been proposed, patented, or kept secret during the last 125 years. Around the knowledge and power of the practical oil refiner not a little mystery still obtains. Each individual oil presents its own problem, and even the same oil by name, obtained under different conditions, involves judg-

ment based on the knowledge of the chemistry involved, to secure the best and most economical results. Furthermore, the use to which the oil is to be put must be considered; for example, one wants acid oil for some paints and neutral oils for foods.

Some four general methods for refining oils have been and are being worked in practice. They are:

1. Treatment with steam (plain or superheated) whereby some coagulation results and many odoriferous substances are driven off. This does not diminish the free fatty acid content of the oil so treated.

2. Treatment with variable amounts of concentrated sulphuric acid (Gower, 1792) under determined conditions of heat and agitation with or without air. The oil contains certain substances which, when flocculated by the acid and temperature, fall down and mechanically (term used in several recognized authoritative books) carry down other impurities. This process does not diminish the acid content of the oil so treated.

3. Heating up under carefully regulated temperature conditions with fullers' earth, bone-black, etc., and filtering. This process also yields an acid oil.

4. Adding caustic alkalies, or alkaline earths, of an amount and strength determined by laboratory experience (Barreswil, beginning nineteenth century), heating to the "break," settling and drawing off the oil which floats upon the soap stock or "foots." This was supposed to give a neutral oil, but not until it had been washed several times with water.

Yet as late as last year a distinguished oil chemist, in a very interesting summary of the "Contributions of the Chemist to the Cotton-seed Oil Industry," said: "The chemist . . . found that the quality of the oil followed the free fatty acid present." An empirical formula has been worked out to show this relationship to the free fatty acid. The rule is: Multiply the f. f. a. by 2 and add 4; that is, an oil showing 2 per cent f. f. a. should give a shrinkage of 8 per cent. This is true only in a general way. I recently had a cotton-seed oil with 1.7 per cent f. f. a., which showed a shrinkage of 21 per cent by the official method of the Cotton-seed Crushers' Association.

The writer quoted above further said: "The chemist's greatest service to the industry has been in the refining of the oil . . ."

Wesson was here referring more especially to edible cotton-seed oil. In that connection Lewkowitsch, the lamented Anglo-German specialist in oil chemistry and technology, has said: "No chemically treated oil or fat can be looked upon as a product fit for human consumption." I confess inability to comprehend this sharp distinction as to what is meant by a "chemical." Oxygen from a chromate is a chemical; oxygen of the air is not. Sulphuric acid is a chemical; caustic soda is not. It may be interjected here that certain statements transmitted by texts and sanctioned by law call for clarification and revision. No treatment of an oil or fat, which involves purification, rendering it palatable, agreeable to the sight and avoids the introduction of constituents which may interfere with normal digestion should be forbidden. For fear of misunderstanding it may be stated here that the method described below complies with all the most rigid laws of all nations and even the above-mentioned uneven discriminations.

An oil that is acid is unsatisfactory as a food. Acid oils corrode the vessels and generate objectionable gaseous products when used as burning fluids. Acid oils corrode the bearings when used as lubricants, so it is desirable to have neutral oils for many purposes. Yet a neutral oil does not "cut" into white lead, for example, so an acid oil is preferred as a paint vehicle; but Gardner has pointed out that the oil should not be too acid.

I have been more concerned with neutral oils and their production, so shall confine my remarks to preparation of that class of substances.

The present customary practice for refining vegetable oils referred to (the fourth mentioned above) depends upon neutralizing the free fatty acids in the crude oil usually by agitating the oil with an aqueous solution of an alkali, the strength and the amount having been previously determined by laboratory tests, agreed upon as a standard, and then heating the mixture during agitation to a suitable temperature until the oil "breaks." The mass is then allowed to stand until the "foots" settle to the bottom of the kettle, when the supernatant oil is drawn off by means of a swivel siphon. According to the process of Chisholm, sodium silicate is added to facilitate the settling. Invariably some "dreg" floats on top of the oil. If this be very great its settling is sometimes facilitated by throwing salt on top of the oil in the kettle. The salt drags down some of the floating "dreg." In any event the oil drawn off is clouded, perhaps on account of the presence of some dissolved soap or globulated moisture or suspended matter—all doubtless colloidal in nature. This oil is then "brightened" after drawing off by throwing in small amounts of fullers' earth, heating again, and passing through a filter press. Sometimes, previous to this treatment with fullers' earth, the decanted oil is heated to 160 to 180 deg. Fahr. in a settling tank to cause the "foots" remaining in the oil to rise to the top, when it is skimmed off.

The time factor in settling (six to twelve hours) of the "foots" materially affects the completeness of the separation referred to above. Coconut oil sometimes requires forty-eight hours to settle. In any event the "foots" is wet with oil. The "foots" also entrains oil. Consequently during the rush season the efficiency of yield of refined oil must be sacrificed for speed and quantity refined. In other words, the more speed in refining, the more loss of refined oil, whatever the analysis, upon which purchase and sale are based, may indicate.

A process which would reduce the amount of oil entrained in the "foots" to a minimum, thus increasing the yield of refined oil, and one which would not be dependent upon the slow subsidence of the "foots" (that is, admit of rapid separation with consequent increase in capacity of a refinery), therefore, seemed to me not only to be desirable, but, if secured, would approximate the highest efficiency one might hope for in such an industrial operation.

I have succeeded in working out such a process, and shall now proceed to describe the principles involved and at the same time demonstrate it to you as an analytical method. I have pleasure in exhibiting to you samples of the crude and refined (by my method) oils from a variety of sources.

The technical laboratory tests with batches of twelve to twenty pounds have been verified in the factory on a commercial scale. Some of the samples exhibited are from factory runs.

The aims to be accomplished are:

1. To reduce the amount of oil entrained in the "foots," thus increasing the yield of "whole oil."
2. To reduce the time of contact of the excess alkali (necessary for the "break" and to secure the best "color") to the minimum.

3. A technological corollary calls for the utilization of any by-products.

It is to be assumed that all oils, good, bad and indifferent, are to be treated. However, this may not be necessary, as in some cases only the good, and perhaps the indifferent, oils are refined under the old practice at some places. Certain foreign markets call for a highly

colored oil, so they do not present the problem of bleaching.

In my investigations, lasting through several years, I have taken various kinds of crude vegetable oils from various kinds of sources with various (extreme) conditions and refined them. In many cases I have been told that no attempt would ordinarily be made to refine a particular oil, as it should be sent to the soap kettle, the corresponding price only being expected. Such oils would have represented much better values if they could have been refined by the usual practice. These oils in every case have yielded to my process, have been refined, and with a saving over the old processes. I may say, however, that China wood (tung) oil, castor oil and aged linseed oil cannot be economically refined by the process. I wish also to repeat that I am referring to the production of neutral refined oils only.

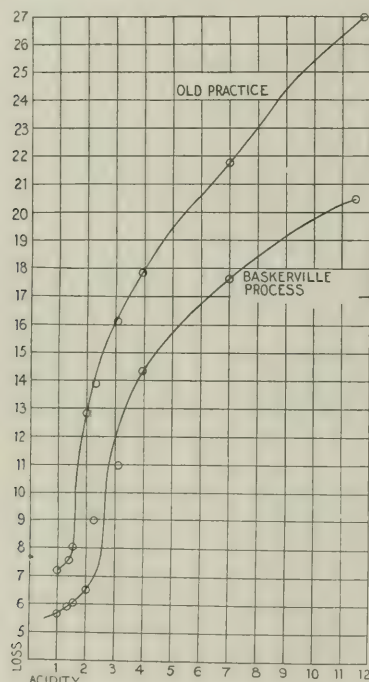


FIG. 1—COMPARATIVE LOSSES FOR COTTON-SEED OILS

If we can get the "foots" into such a condition that it may be filtered and then squeezed, we may reduce the amount of "whole oil" entrained.

If we can do this immediately after the "break" and while the oil is still hot, we shall be able to reduce the time the "whole oil" is exposed to the saponifying action of the excess alkali necessary to secure proper color, avoid the present practice of necessary "cleaning," and the second heating.

I have called your attention to the presence of bodies, which in general terms are called colloids, in oils. These colloids may or may not be colored; may or may not make the oil turbid. I have also shown that some colloids may be and are coagulated by heat, some by acids, some by alkalies, some by salts or electrolytes, and in time will settle out. Colloids that have been coagulated or lumped may be filtered out. Some coagulated colloids in their formation adsorb coloring matter. The problem

of economical filtration on the large scale necessary was one of great difficulty; in fact, so far as I am aware, it was unsolved previous to my investigation. Suitably prepared cellulose fiber will adsorb some coloring matter. It will bring about an agglomeration of the material precipitated from oils by treating the oil with alkalies and heating, and it will bind the particles together so that they may lose their somewhat slimy character and then may be easily filtered away from the oil in which they are produced. Short-fibered "inters" or "delint" is a suitable form of cellulose for some oils.

Therefore I add cellulose, suitably prepared, along with the caustic to the oil to be refined. The "break" takes place normally on heating as in the ordinary process, but the precipitated mass is in such a physical condition that it may be separated from the oil immediately by filtration.

As mentioned above, some colloids, perhaps colored, are thrown down by salts, so in certain cases some salt (1 per cent of sodium chloride) may be added. If there be a slight excess of water present, the sodium chloride serves also to "salt out" and soap in that water. The addition of salt, however, is not necessary in all cases.

I have also discovered that the tendency of the soaps formed by the caustic-alkali treatment to emulsify with the oil, or so to distribute themselves through the oil as to render their separation difficult, may be overcome by subjecting the oil, at a suitable stage of the treatment, to the action of an anhydrous salt which is capable of taking up water of crystallization, the preferred salt being dry sodium carbonate (soda ash), which, as is well known, is capable of taking up one, seven, or ten molecules of water of crystallization, according to temperature conditions. By such treatment the soaps which have already been formed by the treatment with caustic alkali, and which have become so incorporated with the oil as to be incapable of complete separation by ordinary filtration, are hardened or pectised, presumably by dehydration, and are so modified that they are readily separated by simple filtration. Sodium sulphate, which acts in the same way, may be used instead of soda ash.

The process is carried out by adding ordinarily 2 per cent of prepared cellulose (less than 1 per cent real cellulose) and a suitable amount of caustic soda (usually much stronger but actually less in amount than is commonly used). The whole is thoroughly basted by mechanical means and then heated to 45 to 65 deg. C. to produce the "break"; a determined amount of soda ash is added, after which it is filtered. At first some soap may pass through the filter-cloths. In that event, the first filtered oil may be run directly back into the refining kettle and pumped through the press until the oil is "bright." This usually occurs within a few minutes; in fact, the speed of filtration is directly dependent upon the speed of the pumps. This re-filtration also improves the color. This oil is neutral and can be deodorized and bleached, or both at once, or may be

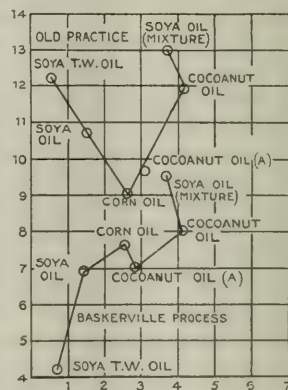


FIG. 2—COMPARATIVE LOSSES FOR SEVERAL OTHER OILS

stored safely. If linters is used, $\frac{1}{4}$ to $\frac{1}{2}$ per cent of the dry cellulose is added.

These ideas are covered by four United States patents granted, Nos. 1,105,743, 1,105,744, 1,114,095, 1,130,698, and others applied for.

The danger of making a whole kettle into soap stock through failure of the refiner to be "on the job" is reduced to a minimum, as in several thousand trials this has not occurred, the trials being made by different people with various grades of oils of different character. In other words, the process is near "fool-proof." Any man of fair intelligence can operate the process, and the air of mystery surrounding the professional refiner is dissipated. The superintendent has a double check on the refinery by weighing the finished oil and cake. The daily reports when summed up should coincide with the annual inventory. I have known of cases where as much as 100,000 pounds of oil have failed to appear in the annual inventory, but were reported daily and had to be charged up to profit and loss at the end of the fiscal year when the operation was under the usual process.

The curves of Fig. 1 have been prepared from a series of cotton-seed oils very variable in character. Fig. 2 shows the comparative losses with several other oils. They show the comparative losses by the normal present practice and my process.

I have also been able to secure a further 1 to 3 per cent saving by subjecting the "cake" to hydraulic pressure. This extra saving is not shown in the charts.

The process is very rapid, the controlling factor being filter-press capacity. A study of plate filter-presses has indicated a preference for a center-feed press making $1\frac{1}{2}$ - to 2-in. cakes. The filter-press problem in connection with the process is not one of filtering area, but cake capacity. Presses, as the Kelly or Sweetland, which are dumped mechanically, meet the conditions better than plate presses. A new Sweetland press recently devised for this process promises the best results. It is provided with bottom exits for the refined oil, and the under bivalve swings through an arc of 165 deg. Monel metal filter-cloth makes the machine practically permanent. By a slight increase in filter-press capacity the output of a refinery may be doubled or even tripled.

UTILIZATION OF BY-PRODUCT

The cake may be converted directly into soap, the cellulose becoming very finely comminuted. It is partially mercerized, partly converted into a colloid, and some of it forms an unobjectionable filler for some grades of soap, especially soap powders.

The cake may be "cut" with acid directly. The cellulose settles quickly in the aqueous layer from the black grease, which latter may be drawn off ready for market or use. When the cake is to be "cut," in order to reduce the amount of acid necessary, I prefer to use salt cake in place of soda ash as the "agglomerator."

A solution of niter cake, the process of Dr. Jeffrey Stewart of Philadelphia, patent assigned to the du Pont de Nemours Company, for the recovery of oil from soap stock, can also be used in cutting the cake. In view of the high price of acid at present, this may serve as an economical method for making "black grease."

Printed instructions for the use of the method in practice or as analytical procedure will be supplied to any who will write for them.

SUMMARY

A process has been worked out, based on scientific principles, for preparing neutral oils, which possesses the following advantages:

1. The actual refined oil obtained is from 1 to 10 per cent more than now secured. Placed at a low average of 3 per cent, the process will save the cotton-seed oil

industry in this country over \$2,000,000 a year when prices are normal. The soja-bean oil industry, just developing in this country, can save 5 per cent. The peanut oil industry can save 6 per cent. The coconut oil industry can save from 3 to 5 per cent.

2. The process takes from one-tenth to one-third the time now necessary. Hence the capacity of the refinery is increased. This is of great importance during the rush season; in fact, its introduction will in economic efficiency perform the same rôle the tungsten filament lamp has played in the electric lighting industry, whereby the light production of a power station has been tripled.

3. The process gives a daily double check on the efficiency of the refinery.

4. The process is applicable to all grades of edible oils, which is not true with the common procedure.

5. Little new machinery is needed. The extra filter-press capacity called for will be more than paid for in the first year's profit.

6. The cost of chemicals is the same or less.

7. The by-product cake may be converted directly into a useful and commercial material.

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Roentgen Rays and Crystal Structure*

(From *Lancet Engineering*, June 2)

To the general public the Roentgen rays remain the X-rays—the name chosen by their discoverer—a scientific mystery, more fascinating than radium, which, after all, does not do much more than shine and decay, a thing a conservative mind does not approve of. That in decaying radium generates helium, and that the disintegration proceeds through an extraordinary series of stages, ranging in time-period from minutes to thousands of years, is hardly understood by people who are quite able to appreciate the wonderful things that medical men have achieved with the aid of Roentgen tubes.

But the rays have done much more. They have helped to establish the actual existence of the atom and to reveal that the atom itself has a structure, and they promise to disclose the structure of the atoms in crystals—i.e., the way in which the atoms are grouped and arranged in solids. The student of elementary science soon grasps that solids are dreadfully complex by comparison with gases. The chemist can analyze solids as well as fluids. He splits a compound into its constituent elements, finds out the relative numbers of atoms of each constituent, counts, in conjunction with the physicist—for it is mainly physical chemistry, of course—the actual number of molecules or atoms, and assigns definite structures to the constitutions of certain substances. Those constitutions are not mere speculations; for compounds have synthetically been built up from their elements on the basis of these researches.

But there science seemed to find its limit. Calcite, it has long been known, is CaCO_3 , like limestone; in the kiln the carbonate behaves as if it were made up of CaO and CO_2 ; in solutions it seems to split into the ions Ca and CO_2 . How are the atoms of Ca , C , O actually grouped in the crystal? If they were differently grouped, their properties would probably be different. What are the forces and the laws? The X-rays promise to answer these questions.

The X-rays first puzzled scientists by penetrating through opaque substances and by refusing to be reflected, refracted, or polarized. But there was a strong suspicion almost from the first that they were, after all,

*An account of the work of the late W. H. Bragg, F.R.S., on the structure of crystals, published in our issue of June 15, 1916, under the title "The Structure of Crystals."

only rays of light, though of a light of extremely small wave-length, too delicate to be examined by ordinary apparatus. That assumption has been fully confirmed. The wave-length of sodium light is 5895×10^{-10} Angström units (A.U.), or 5895×10^{-4} cm., and X-rays have wave-lengths of the order of 10^{-8} cm., about one ten-thousandth of the length of ordinary light waves. In a diffraction grating the spacings between the lines should be of the order of the wave-length of the incident light; that condition is fulfilled by ordinary gratings with about 20,000 lines to the inch. To rule a grating with 10,000 times as many lines would be out of the question; the distances between the lines should be of the order of inter-atomic distances.

The ingenious idea occurred to Prof. M. von Laue then (in 1912) at Munich (he accepted a call to Zürich soon afterwards) to make use of the ordered array of the atoms in a crystal as an X-ray grating. The experiments made by Laue in conjunction with W. Friedrich, P. Knipping, J. Herweg, E. Hupka and others, were surprisingly successful; crystals of zinc-blende, copper sulphide, rock salt, diamond, zinc, sulphur, etc., behaved like three-dimensional gratings. That was the origin of the new line of research. The experiments were made by letting a beam of Roentgen rays pass through a crystal on to a photographic plate; the black central spot produced on the plate was found surrounded by small dark spots of greater or smaller intensity, arranged symmetrically to the center and lying on circles or ellipses passing through the center, each spot representing a reinforcement of the waves in that direction. Crystals of copper sulphate gave such a radiograph, the powdered crystals did not. But long exposures (of many hours often) were required, and the interpretation of the radiographs in all their striking regularity, as given by Laue, was very complex; he published a memoir on the "Diffraction of Short Electromagnetic Waves by a Crystal" in the *Berichte of the Bavarian Academy*, Munich, June, 1912.

In a mathematical discussion of this memoir (Proceedings of the Cambridge Philosophical Society, February, 1913), Mr. W. Lawrence Bragg, of Cambridge, proposed a simpler interpretation of the phenomena, which he illustrated by the diagram, Fig. 1. Let a beam

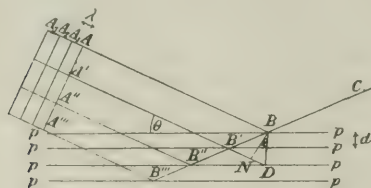


FIG. 1—REFLECTION DIAGRAM

of homogeneous light A, A_1, A_2, A_3 of wave-length λ fall on a series of plane parallel surfaces p (all at the same distance apart d), each of which reflects a small proportion of the incident light and transmits the remainder; then reflection and interference will result as with thin films, except that there are a great many reflecting surfaces instead of the two of the soap film. The wave AB will partly be reflected, at its angle of incidence θ , in the direction BC , and will partly travel on into the crystal; this latter portion is not indicated in the diagram. The waves reflected at B', B'', B''' , etc., will, under certain conditions, pass out in the same direction BC , and in the same phase. To find the conditions, draw BN at right angles to A', B' and produce A', B' until it cuts the plane B'' in D , which will be the mirror image of the point B in plane B'' ; since then $B'B$

$= B'D$, $AB = A'D$, and $ND = B'D$ (the distance by which the rays AB and $A'B'$, and hence also the broken rays ABC and $A'B'C$, will differ) will be $2d \sin \theta$. If DN be equal to the wave-length λ or to a multiple of it, the waves reflected at B and B' and similarly at B'' , etc., will all be in the same phase and reinforce one another. If DN differ only slightly from λ , the difference in phase will become greater and greater as the number of planes increases, and the resultant amplitude at C will practically be zero. Thus reflection (as different from ordinary reflection) will only take place when $\lambda = 2d \sin \theta$. This will be a reflection of the first order, and to mark this we write $\lambda = 2d \sin \theta_1$. If θ_1 be changed to θ_2 , there will be again reflection of the second order for $2\lambda = 2d \sin \theta_2$, and reflection of the third order for $2\lambda = 2d \sin \theta_3$, etc. At angles not satisfying this condition there will be no reflection.

Now in a regular crystal the atoms are probably arranged in parallel planes p , thousands of planes, all at spacings d ; the d may or may not be equal to the distance between two atoms next to one another in the same plane. The planes will not form continuous walls; that is not necessary for reflection, since a cluster of trees or a cloud can reflect sound waves as well nearly as a wall of rock. The atom-bearing planes are set in crystals at intervals of one or two Angström units. The characteristic X-rays used for this study are of the order of about half an Angström unit. This is a pregnant fact, to use the words of Prof. W. H. Bragg; the wave-lengths might easily have been ten or a hundred times the atom spacings, and then the investigation of crystal structure by means of X-rays would have been impossible. The method suggested by Mr. Bragg has been applied with brilliant success by Mr. Bragg himself and by his father, Prof. W. Henry Bragg, up till recently at Leeds, now at University College, London, and in this review we follow mainly the communications made by Professor Bragg, who quite recently lectured upon the subject again before the Institute of Metals and at the Royal Institution. The Bragg method, it may broadly be said, works with reflected rays, while the Laue experiments were with transmitted rays. In their main conclusions the two methods are in entire agreement.

The Bragg relation, $\lambda = 2d \sin \theta$, may be utilized in two ways. When the λ is known, the θ are observed and the d determined; once the d values are determined, the λ can be checked. As the wave lengths λ of X-rays have been measured by independent methods, and the θ can be measured within one minute of arc, the new research admits of considerable reliability. The apparatus used by Professor Bragg is a kind of spectrometer without lenses. A pencil of homogeneous X-rays from an anticathode of rhodium (or some other platinum metal) falls through two narrow slits on a crystal which is mounted on a platform; the reflected ray enters the slit of an ionization chamber (about 5 cm. in diameter, 15 cm. long) charged with a heavy vapor (methyl bromide is now preferred, sulphur dioxide was first used); the resulting ionization is measured by means of an electro-scope and microscope. The crystal or the ionization chamber, or both together, may be turned on the platform to determine the angles at which decided reflection and ionization occur. There is always a slight diffuse reflection from the crystal surface; but the ionization maxima are easily distinguished. As natural crystal faces are often rough or distorted, the crystals are sand-papered or etched with acid, or cleavage faces are taken; elaborate preparation is not required.

The rays used are the characteristic rays of the anticathode; rhodium emits four such rays, or two pairs, the principal ray having a λ of 0.614 Angström unit; the principal ray of palladium has a $\lambda = 0.583$, of silver

0.557 A.U., the wave length decreasing by about 5 per cent as we pass from one atomic number to a higher number (Moseley). The ionization curve found is really the spectrum curve of these characteristic rays; with a rhodium target, therefore, the rhodium rays are repeated in the spectra of higher orders at decreasing intensity; the amplitude of the curve marks the intensity. The method thus does not give any lasting records; the reflected beam might be received on photographic paper—M. de Broglie places a cylinder of sensitized paper round the crystal—but Bragg rarely resorts to photography.

In order to elucidate the relation of the spacings to the crystal form, Professor Bragg calls attention to wall-paper patterns. The position of any point in a pattern may be fixed with regard to two arbitrary systems of parallel lines crossing one another and cutting the pattern up into a number of rectangles or parallelograms. But unless the chosen points of intersection are the same corresponding, representative points, repeating at regular intervals, the parallelogram will not be a "unit" comprising the *ensemble* of the pattern.

Similarly the atoms of crystals are referred to "space-lattices," a kind of scaffolding of three-dimensional axes which, in the cubic system, cross all at right angles and at equal distances apart; in the other crystallographic systems the distances and angles are not all equal. When planes are passed through all the *X*, all the *Y*, and all the *Z* axes, the structure is cut up into cells, cubes, or parallelepipeds. Even the most complicated crystal can be referred to such a fundamental space-lattice, as indicated in Fig. 2. But a cell will not necessarily be a fundamental unit, unless it comprises at least the full number of atoms making up the characteristic molecule (possibly group of molecules) of the substance. Each unit can be considered separately, but to understand the growth of crystals, and the special relations it is better to consider the space-lattice as unlimited in all directions.

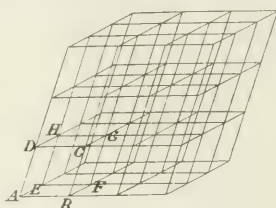
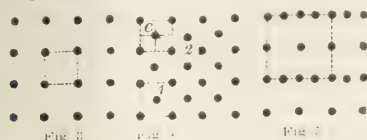


FIG. 2—SPACE LATTICE

In the crystal models the axes are represented by wires, and the atoms by beads strung on them. Supposing the atoms to be spaced quite regularly, as in Fig. 3, each little dotted square (in the wallpaper), or each cube on that base (in the crystal), would represent a unit. In the alternating grouping of Fig. 4 each dotted square would again give a cube (1 or 2), but only one of the two (2) would represent a unit (the *c* in Fig. 4 will be explained presently), and in Fig. 5 four of the



ATOM ARRANGEMENTS

little squares would be required to make up a unit. The relations become clearer when small balls (atoms) are piled upon one another, which can be done in various ways; but the wire models are the most instructive, and when they are so held in the lantern beam (as Professor Bragg does) that corresponding axes and atoms coincide, the arrangement of the atoms in the various planes can clearly be recognized.

When the pencil of X-rays falls on the plane *ABCD* (Fig. 2), the formula $\lambda = 2d \sin \theta$ gives the *d* as distance between that plane and the next parallel to it, *EFGH*. When the pencil falls on the plane *A E H D*, the distance of this plane from *B F G C* is determined. But planes may also be passed, *e.g.*, through *E B C H* and corresponding points, cutting off the level of the edge *A D*; again, the nose of the crystal may be cut off, as Professor Bragg calls it, by a plane through *D* and *E B*; and so on. The values of *d* determined in this way may or may not be equal, but they will always be in definite geometrical relations. The larger the angles of reflection observed the closer will be the spacing.

Yet the deduction of the crystal structure from the *d* is not simple. In the case of a cubical lattice, for instance, the atoms may be arranged to cubes in three ways. When experimenting with rock salt (NaCl) and sylvine (KCl)—cubic crystals, very much alike in all properties—Mr. Bragg found that the *d* were not always in correspondence in the two crystals. There was parallelism when the atoms were referred: (a) to a simple cube (one atom at each corner), or (b) to a center cube (one atom at each corner, one in the center of the cube), but when the atoms were referred (c) to a face-centered cube (one atom at alternating cubic corners, one in the center of a face), as in Fig. 4 (c), the analogy between rock salt and sylvine failed. This was found by considering cubic planes, planes beveling off the edges, and planes cutting off the noses, as mentioned, and in this way it was established that KCl gives a simple cube of type (a), and NaCl a face-centered cube of type (c), while ammonium chloride is one of the rare examples of type (b). The face-centered cube (c) is very common, and the crystals of copper, silver, gold, etc., belong to this class.

So far all these measurements were merely relative, however. Absolute determinations of the *d* can be made when the atomic weight and the density of the material are known, and in the case of rock salt the distance between two planes (cubic faces) was found to be 2.81 A.U. The consideration of the relative intensities of the spectrum lines of the various orders constitutes another very important step. The intensity of a spectrum line depends upon the atomic weight of the atoms in the plane. When all the atoms in all the planes are the same, the intensities should diminish, according to a simple law, with the higher orders, just as in the case of a regular grating. That was found to hold for crystals of elements, and nearly to hold for KCl, because the atomic weights of K (39) and of Cl (35.5) do not differ much. But it did not hold for NaCl (Na = 23, Cl = 35.5). If the atoms of Na and of Cl were arranged in alternating parallel layers, the intensities should indeed alternate, just as in the case of a grating ruled with alternating strong and weak lines. Mr. Bragg correctly interpreted these features, and it follows that his value for the *d* of NaCl (above given), *i.e.*, 2.81 A.U., marks the distance between a sodium atom and the chloride atom next to it.

When the spacings between the parallel planes are not all the same, similar intensity variations should be observed. In the case of the diamond there is reason to assume that each carbon atom forms the center of a small, regular tetrahedron, with carbon atoms at the four corners, from which it is equally distant; the lattice is a face-centered cube all the same. When the model is built up, it is seen that the first layer of atoms lies in the base, the second layer at the distance 1 above the first, the third layer at the distance 3 above the second, the fourth at distance 1 above the third, and so on. It is as if a grating were ruled with lines spaced 1 and 3 divisions apart alternately. Such a grating would not

give any second-order spectrum, and the second-order spectrum of the diamond was indeed found absent. The structure of zinc blende (ZnS) is exactly like that of the diamond; but there layers of Zn and S alternate at the distances 1 and 3, and as the atomic weight of sulphur (32.07) is only about half that of zinc (65.37), the second-order spectrum is weak, but not quite suppressed. The structure also would explain why zinc-blende has a polarity, while the diamond has not, for, with the atoms arranged in alternating planes of Zn and S, it would make a difference whether the light rays struck a zinc layer (coming from the left) or a sulphur layer (coming from the right). Professor Ogg of the Cape, at present working at University College, has quite recently found that antimony and bismuth can be referred to tetrahedra, like the diamond, but the central atom is not equally distant from the others in their cases.

We will briefly notice some more complicated cases. Calcite crystallizes in regular rhombohedra, which ought to be perfectly symmetrical about a certain plane. The X-ray examination shows that layers of Ca and of CO_3 alternate in certain parallel planes; in other directions layers of Ca, CO_3 , O, O succeed one another; the symmetry does not appear to be quite perfect, however; that is to say, the left and right half of a section only coincide when the one side has been slightly shifted (gliding symmetry). Dolomite, which is a double carbonate of calcium and magnesium, is found to be built up of layers of Ca, CO_3 , Mg, CO_3 , Ca, etc., and there is no plane of symmetry—which is in accordance with the views of crystallographers. The complicated structure of magnetite ($\text{Fe}_3\text{O}_4 = \text{FeO}, \text{Fe}_2\text{O}_3$) can be imitated by piling up layers of oxygen atoms and fitting iron atoms into the interstices; some of the iron atoms appear as centers of oxygen tetrahedrons (4 O atoms), in which the iron is bivalent, some as centers of octahedrons (6 atoms of O), in which the iron is trivalent; the two sets have some atoms in common and differ by 60 deg. in orientation.

Professor Bragg's wire models, which can be taken to pieces, also help us to understand a puzzling point. The X-ray examination seems to concern itself merely about atoms, and not to recognize molecules. The one Na molecule in rock salt might equally well belong to any one of the six Cl atoms near it. But it is difficult to say in what condition the molecule really exists in the solid, and the X-ray examination does not entirely lose sight of the molecule. The whole crystal behaves like a big multiple molecule. If, in taking the model to pieces, a definite order is observed, the complex crystals of magnetite, as well as the simple rock-salt cubes, break up into their molecules. That shows that there are various methods of breaking up a crystal, and that the surface of a crystal is more or less like an unsatisfied set of atoms, to which set arrangements of fresh atoms will easily attach themselves—an exceedingly fruitful conception, which would account for the growth of crystals as well as for surface adsorption.

When crystals are heated the spacings between the atoms should widen, and the X-ray lines should be shifted and decrease in intensity; rock-salt crystals show this when heated in an electric furnace while being examined. Similarly, the expansion of crystals in different directions could be determined with very small specimens; the method does not require large specimens. The new method may also disclose why soft metals form hard alloys; further, in which way the hard and soft state of metals of Beilby, the surface films and cement films between the crystals, differ from one another. E. A. Owen and G. G. Blake have studied hard and annealed copper by X-rays. The examination, of course, presupposes a regular arrangement such as crystals offer.

Experiments with glass, which is not crystalline, have failed, we believe, as they were expected to do. On the other hand, O. Lehmann has applied Laue's method to the study of liquid crystals; F. Terada has examined rock salt in the plastic state; P. Knipping has discovered a structure in liquid and in solid paraffin and in wax, and S. Nishikawa and S. Ono (likewise experimenting after Laue) discern crystals in fibrous asbestos, arranged along the fillers, but not in glass threads.

In their main conclusions, the two methods, of Laue and of Bragg, are in essential accord with one another, as we have already stated, and that should be so according to L. Ornstein and others. The objections to the former method are the long exposure, the unavoidable (though, in a sense, useful) presence of X-rays of different frequency under these conditions, the difficulty or impossibility of making quantitative measurements, and the difficulty of interpreting the results; according to G. Friedel, moreover, Laue's method does not bring out the full hemihedral symmetry. The quantitative ionization measurements (though not so accurate as the angle measurements) and the rapid working with homogeneous rays are the advantages of Bragg's method; the constancy of the radiation frequency can be checked by the comparison of the intensities of the different order spectra. Absorption, studied by C. G. Darwin, plays a part in both methods. It is satisfactory that Glocker agrees with W. L. Bragg and his co-workers as to NaCl and KCl, with A. Johnsen as to calcite, with E. Keller as to the diamond, and with P. P. Ewald and Friedrich as to zinc-blende, though not as to pyrites. On the other hand, F. M. Jaeger maintains that the theory is so far inadequate, on either lines, to deal with biaxial crystals; there is still one factor missing in the deductions.

X-ray investigation of crystals is young, of course. But there is a dearth of workers, and the war has cruelly put an end to the life of some investigators and has interrupted the work of others.

By-Products from Coke Manufacturers

In a paper presented at the recent meeting of the American Iron and Steel Institute in New York, Mr. William H. Childs, president of The Barrett Company, New York, gave an interesting account of the present status of the recovery and use of the by-products from coking. He pointed out that the development has not been uniform here and abroad. Practically all of the pitch made in Germany, or in Europe, is used for fuel purposes, whereas in the United States the use of the softer grades of pitch has been carefully developed. In the United States coke-oven gas has been used for general city purposes since 1899 with success and increasing favor. Germany did not do this until 1910, but laid great emphasis on the use of oven gas in gas engines for electric power development. In this direction the United States has remained behind. At the present writing new ovens to the number of 2600 are under contract and will probably be completed by the end of 1917.

Many attempts have been made, mostly in gas retort practice, to increase the yield of ammonia from coal, in view of the large amount of nitrogen retained in the coke. The most promising of them seems to be the mixing of a little less than 2 per cent of caustic lime with the coal to be carbonized. Results for a year at an English gas works showed a gain of 1.68 lb. of sulphate of ammonia per net ton of coal, the operations being benefited rather than otherwise.

The latest coke-oven plants have adopted what is known as the semi-direct or direct methods of am-

monia recovery, in which the gas from the ovens, freed from tar, is led directly into the dilute sulphuric acid, the production of sulphate thus being accomplished without the intervention of washing water or redistillation. In the semi-direct system, which is much used in this country, the preliminary removal of tar involves the production of a certain amount of ammonia liquor, which can be treated in a still and returned to the oven gas before it enters the saturator, or can be made into crude, strong liquor. This process is called semi-direct, as all the ammonia is not made directly into sulphate. A direct system, in which no liquor is made, has also been developed and placed in operation in this country.

Some of the German plants put out a dried and ground sulphate, which, being entirely deprived of moisture by kiln drying, tests over 25.25 per cent NH_3 and brings a slightly higher price. A corresponding grade is made in this country.

Several methods have been proposed for making use of the sulphur in the gas to make sulphate of ammonia, rather than to resort to acid purchased from outside. Among these are the processes of Burkheiser and of Feld. The latter seems to offer a prospect of success, though the alterations in the usual methods of gas treatment are quite radical. It has not been tried in coke-oven work in this country as yet, although a modified form is in operation at the Central Union Gas Works in New York City and a plant is being installed at Chester, Pa.

The German cyanamid capacity is now said to be 500,000 tons per annum, and that of the Haber plant, at Ludwigshafen-on-Rhine, 300,000 tons of sulphate of ammonia, this being equivalent to 800,000 tons of sulphate of ammonia, and an increase of at least 500,000 tons over previous capacity. In order to induce private capital to build these plants, the Government has established a nitrogen monopoly, to continue in force after the cessation of hostilities. While the terms of this arrangement are not known, it is highly probable that any relief that they can get by shipping their surplus product into this country will be taken advantage of.

The prospects are that with the full operation of the existing plants, and those that will come into operation before the year is out, the production in this country for 1916 will exceed that for 1915 by 30,000 or 40,000 tons. With upwards of 2600 new ovens under construction, it is highly probable that the years 1917 and 1918 will register successive large additions. It is not out of the way to estimate the sulphate of ammonia capacity of the country at the end of 1917 as 375,000 tons.

Coke-oven gas is, in a way, the joker among the cards in the by-product coke man's hand. It may be worth a great deal for illuminating purposes, or it may be worth only its fuel value as against coal under steam boilers. In the first instance it brings from the consumer, let us say, about 60c. per thousand cubic feet, or, allowing for purification and distribution, about 30c. net. For fuel under boilers the usual price is about 4c. per thousand, depending on the price of the coal it displaces. Modern coking practice easily recovers 6000 cu. ft. of surplus gas per ton of coal carbonized. At 30c. this would be \$1.80 per ton of coal, as against a credit of 24c. which would be the other extreme.

Where a new plant is under consideration there is an ample reward here for wise planning and successful negotiation. Unfortunately, success in finding such a market for the gas is in many cases a difficult matter. For example, a modern plant of, say, 40

ovens, which is about the minimum and corresponds to a 400-ton furnace, would produce about $3\frac{1}{4}$ million feet of gas per day. This, under ordinary circumstances, would supply a city of at least 150,000 inhabitants.

Authentic reports are at hand which show a yield from a recent coke-oven plant of over 12,000 cu. ft. of gas per net ton of coal, containing less than 5½ per cent of carbonic acid and nitrogen. Of this gas less than 40 per cent of the heat value was used in coking, so that the surplus corresponded to 7200 cu. ft. The coal was a mixture of 40 per cent low volatile and 60 per cent high volatile coal, which would average about 30 per cent volatile. The total amount of heat lost in waste gases and radiation at this plant was less than 4½ per cent of the total heat in the coal.

One important use, namely, for power development in gas engines, has not received the attention in this country that it has in Europe. So far as information is available, the only large gas engine installation using coke-oven gas in this country is at Lebanon, Pa., where four 1200-hp. engines using gas from the Semet-Solvay plant there develop electrical power for operating the Cornwall Ore Banks. According to published data, gas engines aggregating over 200,000 hp. for operation with coke-oven gas has been installed in Europe by three of the principal builders since the year 1904. A guarantee of 1 hp. per hour with 27 cu. ft. of average gas is not considered out of the way, which would mean about 200 hp.-hr. per ton of coal, or for each modern coke-oven the capacity to produce 125 hp. continuously, as long as it is in operation. A battery of eighty ovens would yield 10,000 hp.

The actual recovery of benzol is a relatively simple matter. It is based upon the property of certain high-boiling oils to absorb the crude benzol vapors from the gas, and to yield them up again when heated to a temperature below their own boiling point. The oils employed for this washing are the so-called petroleum "straw" and tar creosote oils. English practice prefers a tar creosote oil distilling from 220 deg. C. to 250 deg. C., although heavier oils distilling from 250 deg. to 300 deg. are also used. All the American benzol plants use the petroleum straw oil because it is cheaper than coal-tar oils and the benzol can be more sharply separated from it in the type of continuous still used.

The washing of oven gas with oil for benzol is practically parallel to the washing with water to recover ammonia, the guiding principle being to bring the gas into intimate contact with a maximum surface of the cool washing liquid. The benzolized oil passes from the washer through a preliminary heater to the still, where the benzol vapors are driven off by a combination of direct and indirect steam. The exit oil is cooled and returned to the benzol washers, while the benzol vapors pass to the condenser and are delivered as light oil. This contains possibly 10 to 15 per cent toluol, and 45 to 55 per cent benzol, with small amounts of xylol and naphthalene. From the crude light oil the refined products are obtained by successive distillation and by treatment with the sulphuric acid and alkali. Benzol is usually made as 50 per cent, 90 per cent, and 100 per cent grades, the percentages referring to the amount that will distill over at 100 deg. C., not to actual purity. For pure benzol the specification requires that 100 per cent shall distill over within a range of 2 deg. C., within which range shall be the true boiling point of benzol.

Until recently there have been few gas works or coke-oven plants recovering cyanids from their gas in

this country. Late developments indicate, however, that several new plants are about to begin operations. Under normal market conditions there is probably little profit to be obtained from its recovery from coal gas.

The coal-tar industry in the United States has passed through two stages and is now entering upon a third epoch. In the first stage, from 1857 when tar was first distilled at Buffalo by Samuel Warren, until about the beginning of the present century, tar distilling necessarily followed "rule of thumb" methods and progressed in volume of material handled rather than in improvement of processes or development of new products and new markets. Great credit is due the pioneers in the industry for building up during this period a substantial business, particularly in the line of roofing material. They laid the foundations and at the same time outstripped in methods and in volume of business the roofing branch of the tar industry in all European countries. It is also important to note that during this epoch, in the year 1887, the H. W. Jayne Chemical Company, Philadelphia, was established for the production of naphthaline, refined carbolic acid, benzol and nitro-benzol. This was the beginning of the plant that in 1896 became the chemical department of The Barrett Company.

The second stage of the industry, comprising roughly the first decade of this century, was a period of engineering development attended by such progress along chemical lines as was necessary to the working out of largely increased production on the one hand, and more exacting demands from consumers on the other hand. The technical specification, as applied to paving, roofing and waterproofing materials, to creosote oil, to crude as well as to refined products, became an important factor. Laboratory control of products was inaugurated, requiring in many instances the working out of new methods for testing and analysis. In 1900 the Barrett company had, outside the chemical department, perhaps four or five chemists in its employ. In 1915 there were over fifty. During this decade and a half, large producers have had to spend much time and money in co-operative work on standards for methods and materials.

We are now entering into the third stage of development. The searchlight of newspaper and popular magazine attention has been thrown upon coal-tar, although it must be said that this naturally dark subject has not been highly illumined by the rays from that quarter. Coal-tar began to be regarded as a sort of Aladdin's lamp, and for many months it was no uncommon thing to receive inquiries for "50,000 gal. of tar a day" from respectable and previously conservative manufacturers of cast-iron pipe, sewing machines or porcelain bathtubs, who contemplated going into toluol at \$4.50 per gal. as a profitable side-line.

"The portion of tar that can be used in making synthetic dyes and chemicals is only 10 per cent of its whole composition. I cannot overemphasize the fact that the continued growth of the tar industry, and its ability to take care of the largely increased supplies that are already in sight, depend entirely upon the disposal, at profitable returns, of the two principal items that constitute the great bulk of the product of tar distillation, viz.: **pitch** and **creosote oil**.

The total United States production of coal-tar in 1915 was approximately 180,000,000 gal., of which 140,000,000 were from by-product ovens and 40,000,000 from gas works. We have, therefore, three distinct types of tar: first, that from horizontal gas retorts, which may be expected to gradually diminish in quan-

tity; second, that from by-product ovens, which it is estimated will reach 250,000,000 gal. in 1917; third, a much smaller but gradually increasing amount of vertical retort tar.

These three kinds of tar differ widely in characteristics. The difference may be roughly expressed by saying that horizontal or old-fashioned gas-works' tar is the heaviest, most viscous and contains a lower percentage of oils and more pitch. It also contains the highest percentage of suspended or "free" carbon—the portion of tar insoluble in benzol. Coke-oven tar occupies an intermediate position. It is usually lighter and contains more oils and less pitch than horizontal gas-works tar. Its free carbon content is lower. Vertical retort gas-works tar is lighter, less viscous and contains more oils and less pitch than coke-oven tar, and is also lower in suspended carbon. In order to meet specifications controlling the sale of products, it is generally necessary to combine two or more tars before distilling. Thus the problems of the tar distiller are rendered more complex by each new type of gas retort or coke-oven that is introduced, and by each change in coking time or temperature at existing plants.

The quality of tar may never be the controlling factor in deciding the type of oven or gas retort, or even in determining the heats and time of coking; nevertheless, some consideration of this phase may be worthy of the attention of coke-oven operators.

The reduction or disappearance of valuable constituents means, of course, that the tar is really worth less than before. In the past, such conditions have not influenced the price of tar. Doubtless the time will come when the real value of each tar, based on its composition, will affect the price.

There are at present about fifty distilling plants located in the United States. Many are naturally in the large cities, where the greatest demand exists for the road surfacing materials, paving pitch and roofing, that constitute the largest items of tonnage. Another reason for having tar-distilling plants located in large cities is the exacting service required in the delivery of road tars and paving pitch, in which hundreds of motor-driven tank trucks are engaged. Hence, freights from gas or coke-oven works are often 25 to 40 per cent of the value of the tar at shipping point.

The transportation, handling through plant, dehydration and mechanical features of tar distilling would require a separate paper. Over 1200 tank cars are now engaged in the transportation of tar and tar products, and on the Atlantic Coast there are about twenty barges of 25,000- to 300,000-gal. capacity. At one of the larger plants there are fifty storage tanks of 1000- to 20,000-bbl. capacity.

There are few if any proper uses for crude tar, both by reason of its varying character and because the presence of water and ammonia is objectionable in practically all cases. However, crude tar can be successfully burned in the same manner as heavy petroleum distillates and residues. At this point it may be well to say that tar itself as well as any of the crude fractions obtained from it, can replace petroleum fuel oils in steam plants, metallurgical furnaces, etc., whenever the relative value of the products makes burning a good economic policy. Tar oils have been successfully used in engines of the Diesel type in this country and abroad. In Germany tar oils are apparently the preferred fuel for these engines. Coke-oven tars average about 16,500 B.t.u. value, and the heavy distillates 17,000.

Pitch comprises from 50 to 80 per cent of the tar,

depending on the character of tar and the hardness of the pitch. Its uses are varied. Long experience in some fields and scientific research in others have determined what physical and chemical properties are desirable in pitches for each important use. In order to produce pitch meeting these requirements the tar distiller has especially to study, select and combine tars of different quality.

It is in the development of soft and medium pitches that the American tar distiller has far surpassed the achievements of his European contemporaries. We have extended the use of pitch into much wider fields, and in addition to that we have devoted infinitely more care to the production of pitches meeting the special requirements of each purpose. Large sums of money have been expended, not only on advertising such uses for pitch as the specification roof and road tar, but on the technical development of these products, and on educating the architects and engineers upon whose decision the choice of materials depends. It was frankly admitted by the delegates from England, France and Germany at the International Road Congress in London in 1913, that in technical work on the use of bituminous materials in road construction, American chemists and engineers were far in the lead.

The tremendous increase in the output of coal-tar from new and enlarged by-product coke-oven plants has made it imperative to find new uses for pitch. One rather promising outlet for very hard pitch is as pulverized fuel, where, in some cases, for metallurgical work, it can compete advantageously with fuel oil. Hard pitch normally contains less than one-half of 1 per cent ash and only about one-third to one-half of 1 per cent sulphur. For these reasons it can be used where pulverized coal would be out of the question on account of much higher ash and sulphur content. Work on another pitch outlet was started by our engineers nearly a year and a half ago, in the line of mixing with coke breeze or non-coking coals to supply the cementing properties necessary for satisfactory coking. It is very interesting to note, by frequent references in the English gas journals within the past few months, that the surplus of pitch in England has caused experiments to be made there along this line.

Conclusions

(1) The by-product coke-oven industry is entering a period of rapid development. The by-product industries must expand to keep pace with it.

(2) This expansion must take place on lines adapted to our own conditions and to the large volume of materials involved. We may learn from foreign experience, but we must not be content to copy their methods.

(3) The great outlet for ammonia is in agriculture, in which direction there seems ample room for development, though it may come slowly and need fostering.

(4) The future field for gas is in an increased use for general city and industrial service, made possible by more widely extended distribution systems and by replacement of natural gas shortages, also in generating power by means of gas engines.

(5) There is an ample supply of benzol, toluol and homologues now recovered from our present domestic consumption of solvents, chemical derivatives and explosives. After the present abnormal conditions are past, the surplus will find ready use as motor fuel.

(6) New uses for tar must be found for an increased production of 100 per cent within two or three years, unless it is to be used as fuel. Refined derivatives, including phenol, cresols, naphthaline and intermediates, will be produced in sufficient amount to meet the

demands of the color, drug and chemical manufacturers. The degree of development in this direction depends on the action of the Government with regard to protective measures and upon the co-operative effort of the industries involved.

The increased amount of cresote oil will tend to keep the price at such a level that European producers will seek to find outlets at home for their surplus.

The outlook for pitch is exceedingly problematical. Although new uses may be confidently looked for, it seems inevitable that a large portion of pitch must find its outlet in the fuel field.

(7) The by-product coke-oven, besides being an integral part of our steel industries, is our main source of benzol, toluol and phenol for munitions and the wide range of chemicals of scarcely less importance. It is also our only operating native source of combined nitrogen for nitric acid, and the only possible one outside of the processes for fixing atmospheric nitrogen.

Chemistry of Portland Cement

The manufacture of Portland cement has grown so that the present output is about 100 million barrels per year. The mechanical part of the manufacture has undergone many changes. An article by George P. Diekmann in the *Journal of the American Society of Mechanical Engineers*, May, 1916, gives an interesting review of the chemistry of Portland cement.

The chemical process is carried out in the same way as laid down by the investigations of Fuchs and Vicat, two scientists of the early part of last century. Of course, the advanced knowledge of chemistry and the researches of eminent men have given us more and truer knowledge of the chemical composition of cement, and in order to throw more light and awaken more interest in research, a prize has been offered by the Prussian Government for the best essay on the constitution and hardening process of hydraulic cements, and efforts are renewed to solve this much disputed problem.

Portland cement is a hydraulic cementing material with not less than 1.7 parts by weight of lime to 1 part of soluble silica plus alumina and iron. The lime necessary to produce Portland cement is found as limestone called calcareous matter, and the silica, alumina and iron are found in clay, called silicious matter; the calcareous and silicious materials are mixed in proper proportions and burned to incipient fusion at a temperature of about 2600 to 2800 deg. Fahr. and the resulting clinker ground, to which 3 per cent of gypsum is added to regulate the setting time. Portland cement should not have more than 1.75 per cent sulphuric acid, which is equivalent to about 3 per cent calcium sulphate or gypsum, and not more than 4 per cent magnesia, although these specifications vary in different countries.

Chemically Portland cement is a salt composed of acid and basic constituents of such a composition that none of the bases are unsaturated. The main elements are silica, alumina and iron, known as the acids, and the lime and the magnesia are known as the bases. When limestone and clay have been intimately mixed and ground together to an impalpable powder, this then represents the mechanical mixture of acid and basic constituents, or what is the same, the silicious and calcareous materials. In subjecting this mechanical mixture of limestone and clay to the influence of heat at about 2600 to 2800 deg. Fahr., the mechanical mixture is converted into a chemical compound, and limestone and clay exist no longer in their original form, but are converted into an entirely new

chemical compound, a clinker, called tri-calcium silicate.

Various theories are advanced on the chemical composition of cement. According to Zulkowsky, there are existing two isomorphous compounds of the di-calcium silicate, the non-ortho active modification, the ortho silicates, the active modification and the basic meta-silicates. The meta-silicate is considered a strong hydraulic, having hardening properties in contact with water. The ortho silicate has no hydraulic properties and disintegrates. In other words, silica, lime, alumina and iron must be present in such a ratio that certain chemical action is produced.

According to Le Chatelier, whose work has long been considered the modern theory on cement, cement is a tri-calcium silicate. Professor Michaelis recently advanced the colloid theory, which might give an entirely new view on the constituents of cements. Clifford Richardson made a very thorough microscopic examination of cement clinker and his studies are very interesting. According to these theories, the total basic constituents of any cement expressed in equivalents should not be greater than three times the total acid constituents expressed in equivalents. According to Michaelis, the composition of the cement should be such that the ratio of the acid constituents to the basic constituents shall be from 1.8 to 2.2 times larger by weight. This formula is the one most used and enables the composition to be judged from the analysis very quickly.

In Portland cement each element performs a certain function, and therefore the elements should have a certain ratio to each other, as follows:

Lime to silica... 2.8:1 minimum; 3.2:1 maximum;
Alumina to iron... 2.5:1 minimum; 3.5:1 maximum;
Iron to alumina... 2.0:1 minimum; 3.0:1 maximum.

The chemical composition of Portland cement is very uniform and is usually as follows: silica, from 20 to 23 per cent; alumina, from 5 to 8.5 per cent; iron oxide, from 1 to 4 per cent; lime, from 60 to 64 per cent; magnesia, from 0.5 to 3.5 per cent, and sulphuric acid, from 1.5 to 2.5 per cent.

There are certain formulae for the calculation of the proper proportion of each raw material in relation to the others according to chemical composition and physical nature. One of the most convenient which is used is a formula according to C. Shoch by which the desired ratio can be determined according to the analysis of the materials which are calculated on the total silicates containing silica, alumina and iron. However, no matter what formula might be chosen, the Portland cement raw mixture contains usually from 42 to 43 per cent lime and 20 to 21 per cent silica, or a ratio of 2:1; this may sometimes be as low as 1.8:1 and as high as 2.2:1.

Portland cement contains usually from 5 to 8 per cent alumina. With an increased amount of alumina the cement becomes quicker setting, and if the alumina content reaches about 9 per cent, the cement becomes very quick setting, due to the formation of a tri-calcium aluminate. If alumina is present in quantities exceeding a certain limit it is considered detrimental, as it not only produces a quick-setting cement, but has a greater expansion power, especially if hardening takes place in sea water or water containing alkaline matter. The aluminates are parts of a cement which are most easily acted upon by certain salts contained in sea water, forming water soluble compounds which in time destroy the cement.

Iron in a cement combines with lime and acts as flux similar to alumina in lowering the fusing point

between the acid and basic constituents. Iron will give cement a darker color. Alumina might be replaced by iron giving an excellent cement for marine work. In fact, there are now manufactured in Germany iron Portland cements which are claimed to be superior to ordinary Portland cements for sea water construction.

The effect of magnesia on cement is still a matter of investigation, but all agree that a large amount of magnesia is detrimental to cement. It is of so much more danger than other constituents as the expansive power of magnesia will occur long after setting. The general specifications call for not more than 4 per cent magnesia, while the German specifications allow a limit of 5 per cent. Candelot in his investigation stated that magnesia produces the same effect as free lime.

In recent years the many accidents occurring in construction where magnesia cements have been used have drawn attention to this question. Magnesia cements give very good results in tests, and masonry made with these cements shows desirable solidity sometimes during several years, but after a certain time swelling begins to manifest itself, and with such intensity that nothing can resist it. Candelot stated that a rod of magnesia cement 1 m. long was found to elongate 26 mm. in three years. Dyckerhoff stated, after very thorough research work in which he studied the effects of magnesia, that when magnesia is added to the raw material or substituted for an equivalent portion of lime, it causes a decrease in strength in the resulting cement if present in a proportion greater than 4 per cent. Cracking occurs only with 8 per cent magnesia or more.

It is known that magnesia compounds become hydrated much more slowly than calcium compounds, and this is evident as although concrete consisting of calcium silicate and aluminate will harden and set in a proper manner, cement containing magnesia either in combined form or as free magnesia will, due to the slow hydration after setting, undergo changes and molecular movements, causing expansion and cracking. The natural cements contain usually from 16 to 22 per cent magnesia, but here the magnesia has no injurious effects as in Portland cement. The trouble lays in the burning, as while Portland cement raw mixture is burned at a high temperature, in effect incipient fusion, forming a very dense clinker, in a natural cement mixture only a moderate heat is applied to drive off the carbon dioxide. The resulting clinker is soft and the magnesia is hydrated here very quickly; the hard clinker obtained with this process is picked out and not used.

The amount of sulphuric acid in a Portland cement should not exceed 1.75 per cent, but according to the German specifications 2.5 per cent is allowed. The presence of sulphuric acid in a cement is due to the addition of calcium sulphate, which is added in the form of rock gypsum or burned plaster before or after grinding the clinker. Portland cement clinker is more or less quick-setting, and, in order to retard or regulate the setting time, a small amount of gypsum is added. The amount depends on the composition of the raw materials—usually from 2.5 to 3 per cent is added.

Portland cement clinker usually contains about 0.1 to 0.4 per cent of sulphuric acid due to the sulphates in the raw materials, which are mostly converted by the high heat to volatile acid and driven off. A small amount of this acid is also due to the ash from the coal, which becomes part of the cement. If the burning or fusion takes place in a reducing atmos-

where, the sulphates will be converted to sulphides, forming mostly iron and calcium sulphides, which will again be oxidized to sulphates. The small amount of calcium sulphate added to cement retards the setting time.

When cement is mixed with water chemical action takes place at once, according to Le Chatelier. The hardening process is due to a deposit of inter-locking crystals from a super-saturated solution, part of the water entering into chemical combination. There are two distinct chemical actions which take place, the setting or hydration and crystallization or hardening process. The process of setting is due to the formation of aluminates of calcium, developing a certain degree of heat, but the addition of calcium sulphate prevents quick hydration by forming sulphate of aluminate of calcium, which hydrates very slowly without developing heat.

Along with the hydration the hardening process is beginning very slowly. The tri-calcium silicate is decomposed by the action of water to mono-calcium hydrate. The process of crystallization begins very slowly, and as time goes on the crystals become more closely interlaced, forming a denser body and attaining a stone-like character, called hydraulic character, and it is this process which makes Portland cement such a high-grade hydraulic mortar. If once formed, no action of the elements can disturb its increasing crystallization, and as Portland cement is the binding medium in concrete, any suitable aggregate will become embodied and form an unseparable bond of natural stone.

Portland cement develops in the hardening process about 40 per cent of its total strength in the first 24 hr., 60 to 70 per cent in 7 days, 80 to 85 per cent in about 30 days, and it will attain its maximum strength in about 6 to 12 months, depending on the season of the year. This explains why a cement of 24 hr. is not as strong as at 7 days, and at 7 days not as strong as at 28 days.

Science Linked with Industry

Presidential address delivered at the dedication of the new Massachusetts Institute of Technology in Cambridge, Mass., June 14, 1916.

BY RICHARD C. MACLAURIN

We are here to dedicate a noble group of buildings to a noble purpose. The buildings speak for themselves. They will form an enduring monument to the skill of the architect, the capacity of the engineers of construction, the devotion of the faculty that has planned so much of their detail, and the splendid public spirit of the anonymous benefactor whose gift they are. That gift has won admiration not only for its munificence but for the unostentatious manner in which it was made and for the patriotic purpose to which it has been devoted. It will have far-reaching consequences for the country at large, for its aim is to strengthen American industry at the base by fixing it firmly on the solid rock of science.

How striking is the change that has come over the world in its view of the relation between science and industry! Each is of venerable antiquity, for while science in its growth has gaged the intellectual development of mankind from the beginning, its application to practical affairs is coeval with the manifestation of the scientific spirit. In the early days, however, the two things, science and practice, rarely, if ever, went together, and were often regarded as antagonistic. To-day we are far removed, indeed, from the aristocratic contempt for practical things so freely expressed by Plato and even by Archimedes

himself. No such feeling has been manifested by the great modern masters of science such as Newton, Pasteur, Faraday, or Kelvin, although a trace of it may be found occasionally among the lesser lights.

We do well to rejoice in this change of heart and outlook, a change that means so much to the world; but in so doing we should not fail to recognize our debt to the past. So we have clothed these laboratories in the forms of classic art, and have done this not merely that students may be influenced by the beauty of their simplicity, but that they may observe how well that art adopts itself to thoroughly modern needs. Thus may they have a practical proof of the error of supposing that old things are of necessity useless and a forcible reminder that much that is most potent in our life to-day has its roots deep in the past. For a somewhat similar reason we have inscribed on the walls of these buildings the names of the imperishable dead in the hope that they may inspire our students with the thought that each succeeding age inherits the intellectual wealth of all that has gone before and fails in its duty unless it makes it its high vocation to hand on the heritage that it has received and to enrich that heritage by contributions of its own.

But although we are not unmindful of what we owe to those who have preceded us, our look must be ever ahead. The opportunity immediately before us is alluring in the extreme. The greatest war in history will inevitably mark the end of one era and the beginning of a new. For some time before the war, but particularly during its progress, the world has been given an impressive demonstration that the methods and the means of science are indispensable in many a practical field. In the new era that is about to dawn we must take our share in making the dominance of the scientific spirit pre-eminent in every phase of industry and practice. In that era no half measures will avail. We must get it into the minds of the rising generation that for success nothing must be done haphazard or by "rule of thumb." All must be orderly and logically planned, resting ever on the solid ground of fact, and industry like science must be matter not of expedients nor of guesses, but of laws.

Our prosperity as a nation, perhaps even our very existence, must depend on the extent to which we assimilate this doctrine. In the great industrial struggle that will follow the present war, and that will go on indefinitely, many of the advantages of this country will be offset by serious disadvantages. If victory be ours, it will be no easy victory, but assuredly we have a splendid opportunity of success if only we organize our industries on a scientific basis. We must train men in the methods of science and make the proper use of these technically trained men when we have got them. This—the adequate supply of properly trained men—is the cardinal doctrine of industrial preparedness recognized by thinking men to-day as one of the greatest necessities of the times.

The opportunity for this country to take and keep the lead industrially is constantly before us in these days, but there is another opportunity seldom, if ever, mentioned, that is in some respects even greater. The center of intellectual achievements in the world has passed in turn from Egypt and Babylonia, to Greece, to Alexandria, to Constantinople and to western Europe. Is it to cross the Atlantic? If this be so, the intellectual leadership must accord with the genius of our people for practical affairs. That genius will inevitably show itself chiefly in industrial pursuits and industry will continue to attract a large proportion of the best minds of the country. Hence we must

have industry linked with science, not merely for the benefit of industry but for the sake of science. Of course, our American science will never grow as it should if it is cramped by a short-sighted policy as to what is useful. But if the value of science to industry be generally appreciated, science will be free to expand in any direction, and if it be pursued with the same energy and intellectual power that have been applied to business, there is no reason why America should not become the intellectual leader of the world.

Here is a great hope and a great national opportunity. The problems that it presents are not local and must be looked at from no merely local point of view. They demand the co-operation of all, and as a step toward that great end, Harvard and Technology, each national in its scope and influence, are here combining for the common good.

And so, in the presence of representatives of other learned societies from all parts of this country and from abroad, inspired by their sympathy and their achievements, we dedicate these buildings to the great cause of science, linked with industry.

Synopsis of Recent Chemical and Metallurgical Literature

Storage Batteries

Theory of the Lead Accumulator.—Plante and Faure considered that when a lead storage cell is being discharged, the PbO , plate changes to PbO and the Pb plate to PbO so that the lead accumulator would be simply what we now call an "oxygen-lift" cell. However, this theory was abandoned at an early date in favor of the double sulphate theory, according to which during a discharge the PbO , plate as well as the Pb plate are changed to PbSO_4 . While this theory has been widely accepted, it has also been opposed by some, and the latest modification proposed is that of CH. FÉRY in a French Physical Society paper (*La Revue Elec.*, June 2, 1916). On the basis of experiments carried out by him jointly with M. Fournier, he proposes the following theory. The "negative" plate only behaves as assumed, being Pb at the end of the charge and PbSO_4 at the end of the discharge. On the other hand, it is claimed that the "positive" plate at the end of the charge is Pb_2O_3 and PbO , at the end of the discharge, so that the total reaction during discharge would be given by the equation $\text{Pb}_2\text{O}_3 + \text{H}_2\text{SO}_4 + \text{Pb} = 3 \text{PbO}_2 + \text{H}_2\text{O} + \text{PbSO}_4$. The change from PbO_2 to PbO , is endothermic and absorbs 9000 calories, while the change from PbO to PbO_2 sets free 12,000 calories.

Cement

Properties of Portland Cement.—A study of the compounds existing in Portland cement is very important to the cement industry. Such work has been undertaken by the Geophysical Laboratory of the Carnegie Institution in Washington, and described by GEORGE A. RANKIN, in the *Journal of the Franklin Institute* for June, 1916.

Ninety per cent of an average Portland cement consists of the three oxides, CaO , Al_2O_3 , and SiO_2 . It is to be expected, therefore, that its properties are due mainly to the presence of the above three components, and that the relatively small admixture of the other oxides exerts at most a wholly secondary influence. It has been shown that good Portland cement can be made from three pure oxides, lime, alumina, and silica, in the proper proportions.

Now, ordinary chemical methods enable us to ascertain the aggregate proportion of each oxide present,

but they yield us no information as to the manner in which these oxides are combined with one another—in other words, as to the substances which actually are present in the clinker and are responsible for its characteristic properties. The determination of this question is very important, for this reason; that, until we know what these substances actually are, we cannot hope to improve the quality in any desired direction, except by cut-and-try methods; and it is generally recognized that such empirical methods are much less certain, and take a vastly longer time to reach the goal, than methods based on a real knowledge of the factors in the problem. The determination of this question has been the object of a very large number of investigations; but the experimental basis of most of this work has been altogether insufficient to decide the several questions at issue. There has been in general a failure to realize the fact that a system so complicated as this can be unraveled only by proceeding systematically, using as a guide the principle known as the phase rule and establishing definite criteria for the recognition of the several substances which occur.

Cement clinker is a mixture of substances of very similar properties, and is, moreover, exceedingly fine grained, as a consequence of which it is a matter of some difficulty to make quantitative determinations of the constituents; but this difficulty can be surmounted by studying separately each of the presumable constituents of the clinker and determining definite values of certain properties which serve to characterize it and to distinguish it from other possible constituents. Accordingly the first problem is to isolate and determine all the possible compounds of lime, alumina, and silica which we may expect to find in Portland cement clinker, to establish their relations at high temperatures, and to ascertain their optical characteristics which constitute the most convenient and satisfactory criterion of the identity of the several substances.

In order to work out this system completely it proved necessary to investigate about 1,000 different mixtures of these three oxides and to make about 7000 heat treatments and microscopical examinations of the resultant products. Each such mixture, which was always made up of especially pure materials, was alternately fused and ground to a fine powder, the fusions being made in a platinum crucible to avoid contamination, in order to obtain a thoroughly-combined product. Each of these products was heated in an electric furnace, the temperature of which was carefully controlled and measured, until all changes had ceased, when it was quickly chilled; and the resultant material was subjected to a complete optical study. This procedure, carried out systematically, enables one to determine the crystalline phases present at temperatures ranging from that at which melting begins to that at which the charge is completely melted; and thus to ascertain the melting temperature and optical properties of all compounds of lime, alumina, and silica which form when any mixture of these three oxides is heated.

The results are summarized as follows: The value of Portland cement depends upon the fact that when finely powdered and mixed with water it forms a hard mass; and the strength and permanence of this mass depend upon the constituents of the cement. The major constituents are tricalcic silicate, dicalcic silicate, and tricalcic aluminate. Of these constituents, the compound tricalcic silicate is the one which hardens and develops the greatest strength within a reasonable time. This most important constituent, which is the one formed with the greatest difficulty, makes up only 30 to 35 per cent of an average normal Portland cement. It may be said, therefore, that the essential process for the manufacture of Portland cement is the formation of

this compound, and that any improvement in this process yielding an increased percentage of tricalcic silicate will increase the cementing value of Portland cement. In order to determine the most economical process for producing tricalcic silicate in the highest percentages, it will be necessary to study the rate of formation of this compound in a series of mixtures of various substances; this, in turn, necessitates the determination of the equilibrium relations of tricalcic silicate at high temperatures in such mixtures. Such a procedure will lead sooner to the discovery of the optimum composition in various cases and for various purposes than the empirical, cut-and-try methods which hitherto have been the only methods tried.

Fire Brick

Effect of Compression Loads on Fire Brick.—Some interesting experiments on the effect of compressive loads in reducing the temperature at which fire brick will soften, are described in the *London Engineer*, June 9, 1916. The experiments were performed by Dr. J. W. MELLOR and Lieut. B. J. MOORE and described by them in a paper presented to the English Ceramic Society of which the above is an abstract.

The apparatus consisted of a cylindrical electric furnace with an inner core of refractory material, sur-

ponential constant. The temperature can be expressed in degrees Centigrade or else in terms of Seger cones. To conform with industrial conventions the latter method has been followed.

(4) The more siliceous the clay, the less the difference between the squatting temperature with or without a load; and, in most cases, the more nearly the composition of the fire-clay approaches that of china-clay, the greater the difference between the squatting temperatures with and without a load. The squatting temperature of china-clay is lowered approximately one cone for every increase of 5½ lb. per square inch in the load.

Iron and Steel

Relation Between Cutting Efficiency and Hardness Tests of Tool Steels.—In a paper presented at the annual meeting of the Iron and Steel Institute in London, Professor J. O. ARNOLD, discusses the lathe efficiency of tool steels in its relation to hardness tests. He states that in recent papers read before the Institute there has been a tendency to regard the Brinell and scleroscope numbers as an approximate measurement of the cutting efficiencies in the lathe. This he states is incorrect as there is no relation between Brinell hardness and cutting efficiency. The efficiency de-

TABLE I

University Steel No.	Type of Steel Compositions nearly Identical for each Type	DURATION OF TESTS IN MINUTES AND SECONDS BEFORE BREAKING DOWN				EFFICIENCY CUBIC INCHES OF STANDARD HARD STEEL SHAFT REMOVED				Brinell Hardness No. Pressure, 3000 Kilos.; Ball, 10 Millimetres Diameter	Scleroscope Hard- ness No. Average of Five Tests
		1st Grind	2nd Grind	3rd Grind	Mean	1st Grind	2nd Grind ^a	3rd Grind	Mean		
1523	Tungsten-chromium	M. S.	M. S.	M. S.	M. S.	47.4	56.3	43.3	49.0	600	82.8
1527	Tungsten-chromium	10 7	11 45	9 26	10 26	54.7	61.4	49.4	55.2	629	80.5
1533	Tungsten-chromium	10 26	11 30	11 31	11 18	48.9	56.7	55.0	53.5	578	80.3
1522	Tungsten-chromium-vanadium	14 17	17 59	13 40	15 19 ^a	72.3	96.2	68.0	78.9	600	80.3
1524	Tungsten-chromium-vanadium	17 2	17 49	16 57	17 24 ^a	91.0	95.2	89.1	91.8	600	75.5
1528	Tungsten-chromium-vanadium	16 2	17 52	16 57	17 24 ^a	84.1	95.7	89.1	89.6	600	76.1
1534	Tungsten-chromium-vanadium	15 21	17 10	15 45	16 27 ^a	79.0	91.6	81.1	83.9	600	81.0

Note.—The Brinell and scleroscope hardnesses were taken as near as possible to the hardened cutting edges of the various tools.

*It will be seen that with both types of steel the maximum efficiency is obtained on the second grindings of all seven tools.

*Duplicate test 629.

*Throughout these tests the cutting edge of the tool was red-hot at the breakdown points, and indeed for about five minutes previous to breaking down.

rounded by granular graphite, which is retained in place by a thick fire-clay cylinder, and this in turn surrounded by an iron casing. Iron electrodes are fastened in connection with the graphite. The clay to be tested is molded in the form of a cylinder and placed on a block which forms the bottom of the furnace. By a lever arrangement something like a piston rod through the top of the furnace different weights can be supplied to the clay to be tested, and the temperature at which the piece fails is observed.

The conclusions from the tests are as follows:

(1) The squatting temperature of fire-clays is reduced by a compressive load. The greater the load, the lower the squatting temperature.

(2) The decrease in the squatting temperature with unit increase of load is directly proportional to the squatting temperature, and equal to k times the squatting temperature.

(3) The relation between the squatting temperature T and the load w , expressed in pounds per square inch, is given by the expression

$$T = C e^{kw},$$

where C represents the squatting temperature of the briquette without a load, k is a constant the numerical value of which is dependent upon the particular clay, on the mode of manufacture of the briquettes, on the grain-size of the clay, etc., and e is the regular ex-

pends almost entirely on the thermal stability of the simple or compound hardenites in the hardness steel. Table I shows tests made on two different types of steel.

Influence of Carbon and Manganese Upon the Corrosion of Iron and Steel.—Some interesting and valuable results on the effect of various amounts of carbon and manganese on the corrosive properties of iron and steel have been obtained in experiments carried out by Sir ROBERT HADFIELD and J. NEWTON FRIEND. The results were described in a paper presented at the annual meeting of the Iron and Steel Institute in London. The authors state that there has been much conflicting information in regard to the effect of manganese in steel, and no conclusive evidence has been advanced. The present research was undertaken with a view to throwing further light upon this intricate problem. Of late years it has been repeatedly emphasized that different corroding media exert very different effects upon iron and steel, no one metal resisting all kinds of corrosion equally well. The authors considered it essential to test the steels in a variety of ways, viz., by exposure successively to tap water; sea water; alternate wet and dry; a process closely corresponding to a changing climate; and by exposure to 0.1 and 0.5 per cent sulphuric acid.

The results are briefly as follows:

The addition of carbon from 0.03 to 1.63 per cent to

pure iron containing less than 0.2 per cent of manganese, results in—(a) A steadily increasing rate of corrosion both in tap-water and in sea-water, slight maxima being observed in the neighborhood of 0.6 to 0.8 per cent carbon. (b) An initial fall in corrosion, with a rapid rise to a maximum with 1.05 per cent carbon in the wet and dry tests. (c) A rapid rise in corrosion to a maximum with 0.8 per cent carbon when exposed to the action of dilute sulphuric acid. Clearly there is some difference of behavior towards all the corroding media in the case of the steels in the neighborhood of the eutectic composition, the specimens showing either a tendency toward increased corrosion or else a most decided increase in corrosion.

The addition of 0.7 per cent manganese to the above steels first results in a very slightly increased corrosion in tap-water, sea-water, and in wet and dry tests, with a carbon content up to about 0.4 to 0.5 per cent. From this point upwards the manganese, generally speaking, affords a slight protection, which is very decided in the wet and dry tests, but is not invariable in the sea-water tests.

A second result of the addition of 0.7 per cent manganese to the above steels is an enormously increased corrosion in dilute sulphuric acid. This is particularly important, since in commercial steels the manganese content frequently ranges from 0.2 to 0.7 per cent, and it is evident that the latter are absolutely unsuited for exposure to acidified corroding media. Just as in the experiments with the steels of 0.2 per cent manganese content, a point of maximum corrosion is observed; but this always occurs with a smaller carbon content in the steels with 0.7 per cent manganese.

By increasing the manganese content to 2 per cent upwards—(a) The corrodibility in neutral solutions is greatly decreased, particularly when the carbon content exceeds 0.5 per cent. (b) The corrodibility in dilute sulphuric acid is greatly enhanced.

The authors emphasize the fact that they have confined themselves exclusively to a consideration of the actual results obtained with the steels without in any way considering the theoretical reasons for the observed phenomena.

Copper and Lead

Decomposition and Reduction of Lead Sulphate.—

A contribution to our knowledge of the behavior of lead sulphate at elevated temperatures is offered by W. MOSTOWITSCH, of Tomak, Russia, in the May *Bulletin* of the American Institute of Mining Engineers. In studying the decomposition of lead sulphate by heat, the author found that partial dissociation, with evolution of SO_2 , begins at 800 deg. C.; that the speed of dissolution is slow up to 950 deg. and quick when the temperature is raised above 950 deg.; that fusion, which occurs between 950 deg. and 1000 deg., takes place only after partial decomposition of normal PbSO_4 . Up to 1000 deg. C. no volatilization of PbO was observed, but above that temperature it was very noticeable, forming a sublimate on the boat.

In the presence of silica the dissociation temperature of PbSO_4 is not lowered. It is marked at 950 deg. and increases as the temperature is raised. The decomposing effect of silica is not proportional with the SiO_2 content, but rather the reverse holds true. Decomposition appears to be governed by the viscosity of the lead silicate which is formed; in the bi- and trisilicate mixtures viscous slag envelopes PbSO_4 and retards action. The most rapid decomposition accompanied by the lowest loss of lead by volatilization is found with a silication lying between the singulo- and the bisilicate and containing from 10 to 15 per cent SiO_2 .

The reduction of PbSO_4 by CO begins at 600 deg. C.;

the salt loses in weight and becomes dark; SO_2 is set free. At 630 deg. C. there are visible pellets of lead, and the loss in weight of 21.58 per cent exceeds the oxygen content, which is 21.11 per cent. All the phenomena prove that a reaction between undecomposed PbSO_4 and reduced PbS is taking place according to the two equations: $\text{PbSO}_4 + \text{PbS} = 2\text{Pb} + 2\text{SO}_2$ and $3\text{PbSO}_4 + \text{PbS} = 4\text{PbO} + 4\text{SO}_2$.

With carbon the reduction, which begins at 550 deg. C., is accompanied by the liberation of SO_2 . At 630 deg. the reduction proceeds more quickly than at 550 deg., the loss in weight is larger, and pellets of metallic lead are seen; the PbSO_4 has been largely changed to PbS. At 700 deg. the reduction to PbS and Pb is completed.

A comparison of the effects of the two reducing agents shows that CO begins to act at 600 deg. C., and carbon at 550 deg.; that the reducing power is increased with the temperature when CO acts more powerfully within the given limits than carbon does, for example, at 630 deg. the CO reduced 74.4 per cent and C only 36.98 per cent of the PbSO_4 .

In applying the foregoing results to reduction in the blast furnace, we have to consider the reducing agents and the temperatures. In the blast furnace the reducing agents are the solid carbon of the coke and the gaseous CO of the ascending gas current which travels at a rate of about 22 ft. per second. The furnace charge receives from 12 to 15 per cent coke. The gases passing from the throat of the furnace at a temperature of from 100 deg. to 150 deg. C. contain CO_2 15 to 21, CO 5.4 to 11.0, and oxygen 0.4 to 1.0 per cent by volume; usually the ratio of CO_2 : CO is as 3 : 1. The reduction of PbSO_4 by carbon and CO is energetic at 600 deg. C., and with it takes place the action of PbSO_4 upon PbS; both reactions occur at a temperature below that of decomposition of PbSO_4 by heat alone. The elimination of sulphur which may amount to from 25 to 40 per cent is therefore largely due to the action of PbSO_4 upon PbS in the upper part of the furnace. An advantage in using blast-roasted lead ore as regards elimination of sulphur lies in the fact that the sulphur is present mainly as sulphate which is readily eliminated as SO_2 and does not increase the matte-fall. The CaO of the limestone added to the blast-roasting charge (CaCO_3 = per cent S + 2 per cent) is converted into CaSO_4 , and this is either reduced at 800 deg. C. to CaS and enters the slag as sulphide, or it is dissociated at 1000 deg. C. by SiO_2 and enters the slag as silicate. The SO_2 of CaSO_4 in blast-roasted ore has therefore as little influence upon the matte-fall as has the SO_2 of PbSO_4 . Slags running high in FeO have been found to hold in solution as much as 7 per cent S; thus two slags made at Stolberg, Rhenish Prussia, with 55 and 38 per cent FeO contained 7.4 and 3.7 per cent S.

The flowing temperature of copper and copper-nickel mattes has been investigated by G. A. GUESS and F. E. LATHE to determine whether copper-nickel mattes might have a lower flowing temperature than copper mattes, and thus aid in accounting for the difficulty thus far experienced in pyritically smelting copper-nickel ores. The results are offered to the American Institute of Mining Engineers for presentation at the Arizona meeting this fall. Both laboratory and commercial mattes were investigated, the former being formed by fusing mixtures of white metal from copper converters and copper-nickel converters with varying amounts of iron sulphide.

The results of the experiments did not show as great a difference in flowing temperature between copper and copper-nickel mattes as was expected. The latter appear to have a flowing temperature from 30 to 50 deg. below copper mattes of the grade usually in blast-fur-

nace work. This slight difference in temperature is not regarded as sufficient to explain the failure in pyritic smelting due to a too early liquation of copper-nickel matte in the furnace. The paper gives tables and curves showing the differences in temperature observed for both copper and copper-nickel mattes prepared in the laboratory and secured from operating furnaces.

Recent Chemical and Metallurgical Patents

Gasoline

Gasoline and Other Volatile Hydrocarbons from Petroleum Residues.—A patent issued to CHARLES S. PALMER of Upper Montclair, N. J., on a process of treating petroleum residues to obtain volatile products, has for its essential feature the use of considerable pressure. The original application was filed on March 2, 1907.

The process consists in treating material such as "Florence," "Boulder," "Wyoming," "California," or "Louisiana" pitches or residues which are non-volatile below 300 deg. C. The residues are first melted in a steam-jacketed kettle, then delivered to a digester in which they are heated. During this treatment which occupies only a few minutes, the pressure gradually increases with the temperature, until a pressure of about 130 lb. per sq. in. is reached. There is then a sudden conversion of the materials present into more volatile compounds, which causes a rapid increase in the pressure without any substantial temperature increase. Apparently endothermic reactions take place which use up the heat as it is supplied.

The digester is connected to a still by a pipe line in which is a check valve which allows vapors to pass over above a certain pressure. The vapors from the digester are collected in the still and distilled separately from the undecomposed residues remaining in the digester. The fractional distillation of the collected volatile products yielded fractions as follows in actual tests: Up to 100 deg. C., about 5 per cent; 100 to 150 deg. C., 10 to 20 per cent; 150 to 200 deg. C., 10 to 20 per cent; 200 to 250 deg. C., 20 to 30 per cent; 250 to 300 deg. C., 10 per cent.

As illustrative of the effect of pressure it is stated that at 200 to 325 deg. C. and 60 to 90 lbs. pressure only 25 to 35 per cent of volatile products are obtained. With the same temperature limits and 100 to 150 lb. pressure, 50 to 75 per cent volatile products are obtained. At pressures ranging from 150 lb. up to 300 or 400 lb., 75 to 90 per cent volatile products are obtained. The first claim of the patent is as follows: "The process of treating petroleum residues of the paraffin series to increase the yield of volatile compounds above that normally obtainable therefrom, which consists in digesting the same in a confined space under a pressure in excess of four atmospheres and not exceeding 400 lb. per sq. in., said pressure being principally autogenous, and at a temperature in excess of 200 deg. C., for a time sufficiently long to induce transformation of the major portion of said materials treated into more volatile products, said temperature being below that point at which sufficient carbonization occurs to substantially interfere with such transformation, and said digesting being conducted with the treated materials being continually subjected to the pressure throughout the said digesting period of the evolved volatilized compounds undiluted by added aqueous vapors." (1,187,380, June 13, 1916.)

Electrolytic Processes

Process of Making Formic Acid.—A process of making formates and formic acid by the action of an

alkali amalgam on an aqueous solution saturated with carbonic acid gas, is patented by MOOSHUGH VAYGOUNY, of Berkeley, Cal., and assigned to the Royal Baking Powder Co. The process can be readily understood by references to the illustration, Fig. 1. A is a suitable container of non-conducting material, having on the bottom a layer of mercury B. Another vessel C, open at both ends, dips into the mercury B. An

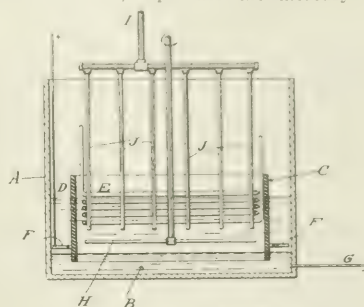


FIG. 1—FORMIC ACID CELL

anode F of platinum, and a cathode G, connected with the mercury, are provided. A strong solution of potassium hydroxide is placed in the space D, and water is placed in the inside space E. Carbonic acid is introduced into the water in E by pipes J, and the solution is stirred by stirrer H.

As a direct current is passed from F to B, an amalgam will form in the mercury. By diffusion, assisted mechanically by stirrer H, or by rocking the cell, this amalgam is caused to travel to chamber E. Here reactions take place which form bicarbonate and formate. Potassium hydrate and hydrogen are first formed, the hydrate then combining with the carbonic acid to form bicarbonate and the hydrogen reducing the carboxyl grouping to the formate grouping. The temperature is kept below 40 deg. C., and the solution is allowed to become concentrated enough in formate so that the bicarbonate will be practically insoluble, thus effecting a separation of these two. The formate solution may be evaporated and crystallized and the formate worked up into formic acid. (1,185,028, May 30, 1916.)

Electrolytic Preparation of Tartaric Acids.—An electrolytic process of making tartaric acids from gly-

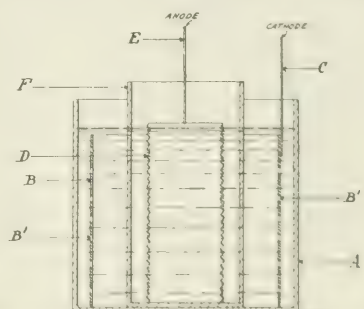


FIG. 2 ELECTROLYTIC CELL FOR TARTARIC ACID

oxylic acid or glyoxalates is patented by MOOSHUGH VAYGOUNY, of Berkeley, Cal., and assigned to the Royal Baking Powder Company. The process is carried out in a cell made of wood or other non-conducting mate-

rial. In Fig. 2, A represents the container, B the copper cathode with perforations B', D the platinum gauze anodes, and F a diaphragm. The material used as the diaphragm is not mentioned.

Into the cathode space of the cell is placed a solution made up as follows: 500 c.c. contain 32 gr. potassium glyoxalate, 20 gr. potassium sulphate, and 0.5 gr. potassium hydroxide. For this quantity of solution the cathode surface should be about 200 sq. cm. About 60 cc. of 5 per cent sulphuric acid is introduced into the anode chamber. The cathode solution is agitated and electrolytic reduction is carried on with a current density of about 1 to 4 amp. per sq. dcm. The temperature is kept at about 25 deg. C. and should not exceed 40 deg. C. In about 2½ hr. reduction is complete. The potassium sulphate is added to increase conductivity and prevent glyoxylic ions from being carried into the anode compartment. The solution should be neutral or slightly alkaline.

After electrolysis, the solution consisting of potassium sulphate, potassium tartrates, and small amounts of oxyate and glycolate, is treated with calcium sulphate to precipitate the tartrates. The solution is filtered and the tartrates (racemic and meso) are separated by well known methods. (1,181,555, May 2, 1916.)

Separator for Electrolytic Oxygen Cell.—A separator of rubber-covered metal designed to be used in an electrolytic oxygen and hydrogen cell such as described in patents No. 1,172,886 and 1,172,887 (reviewed in our issue of March 15, 1916, page 342), is the subject of a patent of HENRY R. SWARTLEY, Jr., of Manhasset, N. Y. (assigned to Davis-Bournonville Company of Jersey City, N. J.). In the cell described in the above-mentioned patents the anodes are surrounded by trough-shaped separators, from which are suspended asbestos sacks which serve as the diaphragm. The separators should be capable of withstanding caustic solution and oxygen, and should be non-conducting. The present patent states some of the objections to various materials. Glass, while not entirely unsuitable, is subject to attack by the caustic electrolyte, and is fragile. High quality, vitreous porcelain presents manufacturing difficulties, and is also fragile. Hard rubber does not have sufficient rigidity. The separator with a core of metal and a covering of hard rubber is stated to produce a practical and efficient separator. The core may be drawn in a press to the desired shape, the rubber is applied in a plastic condition and then vulcanized. (1,176,105, March 21, 1916.)

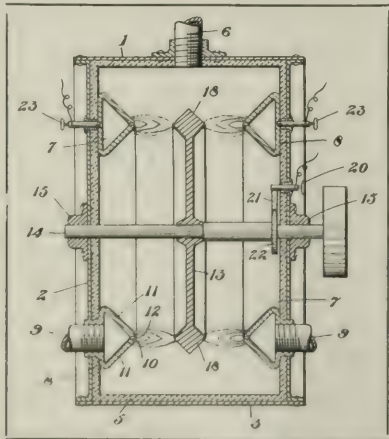


FIG. 3—INSIDE VIEW OF FURNACE

Nitrogen from Air

Electric Nitrogen Fixation Furnace.—A novel method of forming the arc in an atmospheric nitrogen fixation furnace is described in a patent of JAMES S. ISLAND of Toronto, Ont., Canada. Two sectional views of the furnace are shown in Figs. 3 and 4. Fig. 3 is a longitudinal vertical section and Fig. 4 an end vertical section. The outer casing 1 has a silica lining and is shaped as shown; 7 represents tubular ring-shaped members, triangular in shape, as shown, and having perforations 11 in them to allow of a distribution of the air which comes in through pipes 9. The rotating

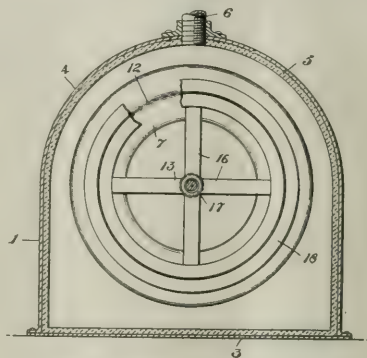


FIG. 4—END VIEW OF FURNACE

element 13 has four radial arms holding diamond-shaped sections 18. Binding posts 23 are connected to two or more terminals of a source of polyphase current and a brush at 22 connects with the rotating element and binding post 20. The arc forms when the current is on and the arc is an annular one, due to its being drawn out by the rotating element. (1,179,927, April 18, 1916.)

Miscellaneous

Extraction of Radium From Carnotite.—A process of recovering radium from carnotite ores or concentrates by treatment with sulphuric acid is the basis of a patent granted to HERMAN SCHLUNDT of Columbia, Mo. The inventor has found that a selective extraction of radium can be made by concentrated sulphuric acid, and that the radium sulphate and accompanying barium sulphate, which are soluble in the hot concentrated acid, can be separated practically completely by mere dilution with water. The ore is ground to 20-mesh and boiled with sulphuric acid at about 60 deg. Baume, until a temperature of 230 deg. C. is reached. The acid liquor is then separated from the ore while still hot; the residue is washed with concentrated acid, and from the clear acid liquor thus obtained the radium is recovered by diluting with water. In practice the quantity of water is from five to ten times the volume of acid. After removing the concentrated acid from the residue the latter is washed with water, yielding a blue liquor containing vanadium and uranium compounds. The latter also are found in the dilute acid liquor from which radium sulphate has been precipitated, and by concentrating these liquors, uranium and vanadium compounds tend to crystallize out, while the concentrated acid can be used for treating further ore. (1,181,411, May 2.)

Production of Phosphorus in the Blast Furnace.—A process of producing phosphorus and its compounds, together with phosphoric alloys of the metals, by smelting natural phosphates with metallic ores and fluxes in a blast furnace, is outlined by JOHN J. GRAY, JR., of Rockdale, Tenn., in a patent recently granted him. Tri-

calcium phosphate, silica, coke or charcoal, lime or other basic material, and ores of iron, copper, nickel, etc., are smelted in proper proportions in a blast furnace. Part of the phosphorus passes out of the furnace with the other gases and is recovered as red phosphorus, orthophosphoric acid or in any other desired form. The balance of the phosphorus is combined with the metal derived from the ore being smelted, and is recovered as an alloy of such metal. The process results in a high recovery of phosphorus, due to the maintenance of a molten bath of metal and slag in the furnace, which facilitates the escape of P_2O_5 vapors. The inventor claims that his process obviates the difficulties formerly encountered in attempting to recover phosphorus by blast-furnace treatment. (1,168,495, Jan. 18, 1916.)

Metallurgical Furnaces

Roasting Furnace.—A method of constructing superposed desulphurizing furnaces, patented by HARRY H. SROUT of New York City and assigned to the General Chemical Co., has for its object the regulation of heat distribution and control of temperature on each of the several hearths of the furnace. This is accomplished by a system of flues and conduits, whereby air is caused to extract heat from zones of high temperature and transfer it to zones of low temperature. (1,181,183, May 2, 1916.)

Agglomeration of Sulphides for Pyritic Smelting.—JAMES H. PAYNE of Baltimore, Md., has patented a process of agglomerating sulphide ores or concentrates, with the retention of substantially all the sulphur contained in the original material. For this purpose the ore is heated to incipient fusion in a rotating kiln in a reducing or neutral atmosphere. On discharging from the kiln the material flows into molds and is cooled by water sprays without opportunity for oxidation. The product is specially adapted to blast-furnace smelting where sulphur is utilized as fuel. (1,181,244, May 2, 1916.)

Recovery of Sulphur in Roasting Sulphide Ores.—A furnace particularly adapted to the roasting of sulphide ores and the recovery of the sulphur is patented by HOWARD F. WIERUM of Upper Montclair, N. J. The

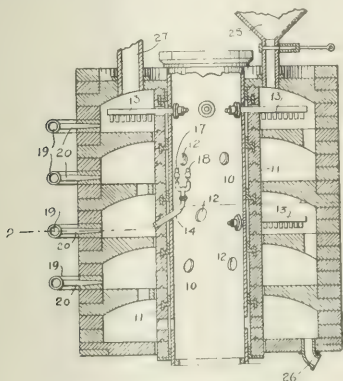


FIG. 5.—ROASTING FURNACE

furnace, illustrated in Fig. 5, is of the superimposed-hearth type, and the particular improvements consist in means for introducing steam into the hearths through tangential openings and applying fuel flames to the ore by burners placed on the inner revolving shaft of the furnace, at a point slightly in advance of the rabble arms or immediately following them.

In the illustration, 10 represents the inner hollow

shaft, and 12 indicates openings for rabblers. A burner is shown at 14, being placed slightly in advance of the rabble arm on that hearth. On the outside of the furnace is a bustle pipe 19 through which steam is delivered to tangential inlets 20. It is claimed that this arrangement of burners and steam pipes offers advantages over that arrangement where burners are on the exterior wall of the furnace and steam inlets are directed diametrically across the hearths. (1,162,894, Dec. 7, 1915.)

Treatment of Ore and Recovery of Sulphur.—A furnace in which several operations are conducted consecutively is patented by UTLEY WEDGE of Ardmore, Pa. It consists of superimposed hearths constructed in muffle form, the furnace being divided into three zones of three hearths each. In the upper zone it is designed to eliminate the sulphur from the ore, and to maintain such an atmosphere, by the introduction of steam, that the metal will be converted to the oxide and the sulphur eliminated without oxidation. In the second zone the oxidized metal is subjected to the action of reducing gases, whereby the oxide ore becomes "metallized." The lowest zone of three hearths is intended as a gas producer where carbonaceous matter is burned or distilled, the gases being conducted to the upper and intermediate zones of the furnace as needed.

In the upper zone the oxygen for oxidizing the metal is provided by the decomposition of steam. Atmospheres of 4 or even 6 per cent of oxygen will oxidize metal with inconsiderable oxidation of sulphur, and carbon dioxide will do the same at the necessary temperature. The practical range of temperature for the vaporization of sulphur and the oxidation of metal in the case of iron sulphide is from 1400 deg. to 1600 deg. Fahr.

Conducting the operations as a continuous process effects economy in fuel. The ideal condition would be to generate a strongly reducing gas in the lower zone for delivery at a high temperature to the intermediate zone where the oxidized metal is to be "metallized." After the gas had performed its function in the intermediate zone and having lost to some extent its reducing character, it could be conducted to the upper zone. (1,169,444, Jan. 25, 1915.)

Combined Sintering and Smelting Apparatus.—In several patents granted to ARTHUR S. DWIGHT of New York City apparatus is shown for the combined and continuous treatment of ore by first sintering into a rigid cake and then smelting in a reverberatory furnace. The sintering apparatus is of the type commonly known as the Dwight-Lloyd, consisting of a series of grate-bottomed pallets receiving a charge of ore to be sintered, and successively carrying the charge under an igniting mechanism and over a chamber from which air is being exhausted, with the result that the sulphurous material burns and causes the entire mass to agglomerate into a porous, rigid cake. In the present invention this cake is continuously discharged into a smelting furnace, whereby the heat of the sinter is economized in the smelting operation. The smelting furnace is of the reverberatory type, with fuel-oil or other burners so disposed that their flame will impinge on the entering sinter and fluxes and cause them to separate into matte or metal and slag in the usual manner. (1,169,069-139-384, Jan. 18 and 25, 1916.)

Industrial Preparedness.—The June issue of the *Journal* of the American Society of Mechanical Engineers contains a full account of the exceedingly interesting discussion on "organizing for industrial preparedness" at the New Orleans meeting of that society, April 11 to 14, 1916.

Novel Construction of Storage Buildings

The Griffin Construction Company, Atlanta, Ga., is erecting two cotton-seed storage buildings for the Buckeye Cotton Oil Company's Atlanta mill. The type of construction used is novel and also new for this purpose.

By using a type of tile in which there is a U-shaped groove for holding reinforcing rods the boiler plate originally specified was done away with. In this way it has been possible to reduce the construction cost to as low a figure as \$3.50 per ton of material stored. The buildings are absolutely fireproof, being built of concrete and fireproof tile reinforced with steel. The roof of the buildings will be of steel.

The two buildings are each 75 ft. in diameter and 60 ft. high, having a total capacity of 7000 tons. The floor is of concrete and the foundation extends about 3 ft. below the surface, resting on heavy clay. Fig. 1 is an outside view of the two storage buildings, while Fig. 2 shows clearly the special construction of the tile. Corrugated steel bars placed in the "U"-groove are held in place with concrete. Wet, heavy cinders are placed in the tile under the rods to keep the concrete around the rods. In the first 25 ft. of tile two $\frac{1}{2}$ -in. bars were placed in the grooves, in the next 25 ft. of tile $\frac{5}{8}$ -in. bars are used and in the top 10 ft. of the structure $\frac{1}{2}$ -in. bars. The bottom 10 ft. have two thicknesses of tile while above that point one thickness is used.

The cotton seed is put into the buildings from the top at the center, thus making a cone-shaped pile tending to push down on the sides of the walls instead of sideways. The danger of the walls bulging out is thereby decreased. An "A"-frame steel tunnel runs through the center on the bottom of each building in which a conveyor will be placed which will be used to remove the seed.

Not only is the cost of the structures reduced to the low figure of about \$3.50 per ton of material stored, but by this type of building the insurance rate is cut down to practically nothing.



FIG. 1 TILE FOR STORAGE BUILDING CONSTRUCTION



FIG. 2—STORAGE BUILDINGS

Eight storage buildings of almost similar construction are being built for Swift & Company's mill at Augusta, Ga. W. M. Griffin is the designer.

A Modern Hydrated Lime Plant

The Vermont Marble Company of Proctor, Vt., have just put into operation one of the finest rotary kiln and hydrated lime manufacturing plants in existence. This plant is located at West Rutland, Vt., and was built for the purpose of utilizing waste products from the various operations of the company, their purpose being to turn this waste into valuable chemical, hydrated and agricultural lime products.

The waste material being brought in from the quarries and factories is discharged directly to a No. 6 crusher, unless the lumps are so large that an earlier preparation is required, in which case the material is elevated and put into the large 60-in. x 48-in. Superior jaw crusher. This crusher reduces the stone to 6 in. and under, and the discharge from the crusher is arranged to flow directly into the No. 6 gyratory crusher. Leaving the No. 6 crusher, the limestone is lifted and discharged directly into a rotary screen which eliminates the fines, allowing the coarser material to pass to a 36-in. x 18-in. roll crusher, which reduces to the same fineness as the screen product, both streams flowing directly to a common elevator discharging onto a belt conveyor. At this point the very fines are screened out and conveyed over to the Pulverized Agricultural Limestone Department. The coarser material is discharged to a large circular storage tank, for night operation or for making the operation continuous, and also to the large storage bin above the rotary kiln.

The kiln department has been made sufficiently large so that a second complete unit can be installed, each



HYDRATED LIME PLANT OF VERMONT MARBLE COMPANY

unit consisting of one 8-ft. x 125-ft. rotary kiln with the storage bins and one 5-ft. x 50-ft. rotary cooler. The storage bin above the kiln is arranged with a cradle type of feeder operated from the kiln-driving mechanism, so that the flow of the material is under control at all times.

The kiln is fired by producer gas which is generated in a separate building and led over to the kiln by means of a gas flue. The discharge from the rotary kiln flows by gravity directly to the 5-ft. x 50-ft. rotary cooler. The burned lime discharging from the cooler flows directly to an elevator discharging into the two large oxide bins, through screens which eliminate any coarse or foreign unburnt material.

One of these oxide bins is arranged to feed directly into an elevator discharging to a "Kritzer" six cylinder hydrating machine. The other oxide bin is so arranged that its contents can also be conveyed to the "Kritzer" hydrator, but this bin was installed primarily for the purpose of loading the lime in oxide form directly into cars for shipment.

The hydrating equipment consists of the following:

- 1—No. 4 six-cylinder Kritzer hydrator.
- 2—Air-separating and dust-collecting outfits.
- 2—Beater mills.

Following this equipment there is installed a large compartment bin arranged for packing the various qualities of lime products in a "Bates" four-tube lime packing machine located below, a dust collector system is also installed in connection with this packer.

The stock house is arranged for the storage of the hydrated lime packed in bags. This building has a capacity of from 1500 to 2000 tons.

In the gas producer house the fuel for burning is brought in and discharged directly into a hopper below the track and is then carried by means of a belt conveyor to a crusher discharging directly to an elevator discharging to a belt conveyor leading to the bin above the gas producer or discharging directly to the covered coal storage. This storage has a capacity of from 250 to 300 tons. The gas producer is of the "Chapman" mechanical type, and this producer installation is modern in every particular.

In general, the buildings are of steel frame construction covered with corrugated iron siding and roofing. The various machines throughout the plant are amply proportioned for the various operations and each machine is driven by individual motors.

The power for operating the plant is received from the hydro-electric stations owned by the Vermont Marble Company.

The whole plant is laid out for future extensions.

There is also a department for pulverizing lime for agricultural purposes. This equipment consists of one 33-in. Fuller Lehigh pulverizer with its accessories. An additional stock house and shipping facilities are arranged in connection with this department.

This plant has a capacity of 75 tons of hydrated lime daily and 50 tons of agricultural lime, and in addition to the above, arrangements have been made so that crushed stone for fluxing or other purposes can be shipped.

The large crusher has a capacity of some 240 tons per hour which is sufficient for all later extensions, but this crusher was installed originally for the purpose of reducing large lumps which otherwise could not be handled satisfactorily.

This plant is the most modern rotary-kiln hydrated lime plant in existence. It was designed and constructed by the Fuller Engineering Company of Allentown, Pa.

Large Single Cylinder Engines for Rolling Mills

A single-cylinder engine which has many points of interest and which is finding use in rolling mills, due to its capacity for extreme overloads is the so-called "uniflow" engine. This engine owes its efficiency to the reduction of the loss by initial condensation. The exhaust is at the center of the cylinder, and the engine is, therefore, suitable to wide temperature ranges. Expansion from boiler pressure down to condenser pressure may be carried out in one cylinder with steam economy equivalent to a tandem compound engine. Tests have shown that 200 per cent load can be carried with only 10 per cent increase in steam consumption.

Uniflow engines have been installed for rolling mills in Germany, one of the largest engines on record having a maximum continuous capacity of 6300 hp. and a short duration peak load capacity of 8000 hp. The average load is 4000 hp. This engine is a 67 in. by 55½ in. at 120 r.p.m., installed at the Röchlingschen Steel & Iron Works at Völklingen, built by Erhardt & Semmer, operating with steam at about 130 lb. pressure and 525 deg. Fahr., total temperature (169 deg. superheat) and drives a 30-in. three high mill. A second engine of the same make has a capacity of 1600 to 2400 hp. and is 43 in. by 51 in. at 120 r.p.m., being installed at the Rombacher Iron & Steel Works.

In this country the first uniflow engines for rolling mill work are those now under construction by the Nordberg Manufacturing Company, Milwaukee, Wisconsin, for the Youngstown Sheet & Tube Company, Youngstown, Ohio, the larger to drive a 12-in. rod mill, the smaller a 9-in. rod mill. The general design of the cylinders is shown by the longitudinal section of Fig. 1. The cylinder is a plain cylindrical casting, all valve chambers and steam passages being contained in the heads, bolted to the ends of the cylinder. This prevents distortion and strains due to expansion and contraction with the use of high pressures and superheats. The steam valves are of the poppet type, the valve cages being separate castings which are ground into the heads with a steam tight joint. The valves are of the double beat, balanced poppet type and no packing is required for the valve stems, which are accurately ground and polished and work in ground and lapped bushings. The valves are operated from lay shaft by a releasing valve gear with spring dashpots, the cut-off being under control of the governor through the wide range of loads. The steam enters the cylinder at the bottom, sweeping up over the heads and jacketing them before entering the valve at the top. The exhaust is through the ports

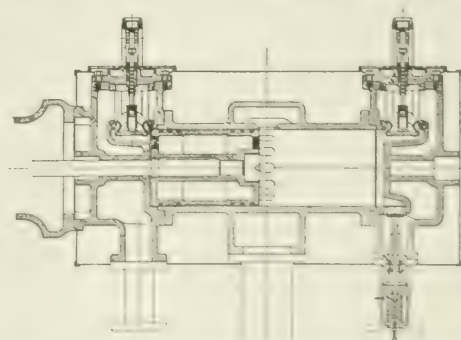


FIG. 1 LONGITUDINAL SECTION OF CYLINDER OF NORDBERG POPPET UNIFLOW ENGINE

in the center of the cylinder uncovered by the piston near the end of its stroke. Relief valves of the poppet type with cataract dampening device are located near the bottom of the heads. In case of loss of vacuum and over-compression these valves automatically open and connect the clearance space of the cylinder with the steam space in the head and the communicating steam piping. The steam conditions will be approximately 170 lb. pressure, 75 deg. superheat, and 20 in. vacuum, steam being condensed by barometric jet condensers.

The larger engine is 44 in. by 50 in., 110 r.p.m. and will have a capacity from 700 hp. to between 3000 and 4000 hp. The weight, including 110,000 lb., 10 ft. flywheel, will be 480,000 lb.

The second engine is a 37 in. by 48 in. at 110 r.p.m. and its weight, including a 90,000 lb. flywheel, will be 360,000 lb.

Alunite in British Columbia

Deposits of alunite have recently been discovered on Vancouver Island in British Columbia, according to Commerce Reports. The analysis of the alunite-bearing rock shows a lower potash content than the high-grade deposits in Utah. Following are analyses of three samples taken from different places in the deposit.

Vancouver Alunite.	No. 1	No. 2	No. 3
Silica.....	52.00	55.65	44.40
Alumina.....	19.85	16.30	21.80
Sulphuric acid.....	16.00	15.10	21.40
Oxide of iron.....	2.45	2.15	7.70
Potash.....	5.60	4.30	4.50
Water, etc.....	4.40	6.50	7.20
Total.....	100.00	100.00	100.00

The results of the above analyses might be compared with three typical analyses of the alunite from Marysville, Utah:

Utah alunite	18	19	Dana
Alumina (Al ₂ O ₃).....	37.18	34.40	37.00
Ferric oxide (Fe ₂ O ₃).....	Trace	Trace	Trace
Sulphuric trioxide (SO ₃).....	38.34	36.54	38.60
Phosphorus pentoxide (P ₂ O ₅).....	.58	.50	.....
Potassium oxide (K ₂ O).....	10.46	9.71	11.40
Sodium oxide (Na ₂ O).....	.33	13.08	13.00
Water (H ₂ O plus).....	.05	.11	.....
Water (H ₂ O minus).....	.22	5.28	.....
Silica (SiO ₂).....	100.10	100.18	100.00

There is a possibility that more extended investigations of these deposits may bring to light a higher grade of rock. This possibility is shown by the fact that a small sunken island some little distance from the mainland contains rock of a much higher potash content than any of the samples above enumerated from Vancouver, all of which were collected at a short distance from the coast and on the hillsides.

Raw alunite has already been largely used directly as a fertilizer with manifest advantage. The roasted mineral, however, gave double the yield in increasing the crops when experimental comparisons were carried out on similar tracts of land.

Moving Pictures at the Second Exhibition of Chemical Industries

The many favorable comments received on the showing of the motion picture films at the 1915 Exposition of Chemical Industries, led the management of the coming Second National Exposition of Chemical Industries to be held at the Grand Central Palace, New York City, week of Sept. 25, to arrange a motion picture program broader in scope than that prepared for the former exposition.

Many films have been secured during the past six months from large industrial corporations throughout

the country through the Bureau of Commercial Economics at Washington. These motion picture films will be shown daily during the Exposition and will be of special interest to every visitor.

Among the films already arranged, are the following showing:

The Match Industry.
The Rubber Industry.
Manufacture of Explosives.
Varnish Manufacture.
Silver Mining.
Mining and Manufacturing of Iron.
Making of Blotting Paper.
Accident and Fire Prevention.
Manufacture and Use of Fertilizers.
Manufacture of Steel.

The motion picture program will include films of such industries that are dependent upon chemistry.

Arrangements have also been made to exhibit the motion picture film taken of the members of the American Chemical Society in Danville during their Spring meeting in April.

The managers report they have at this time twice the number of exhibitors they had last year at the Exposition, and much new apparatus and processes will be exhibited for the first time at the coming Exposition. In no other exposition of any kind can the technical or business man find so much of vital interest and real immediate benefit to repay him for a visit.

Personal

Mr. G. M. Bissel has become associated with the steel-car sales department of Kilbourne Jacobs Mfg. Co., Columbus, Ohio.

Mr. J. A. Burgess has resigned as superintendent of the Wonder Nevada Mining Co., to become general superintendent of the United Eastern Mining Co., Oatman, Ariz.

Dr. Frank K. Cameron, formerly in charge of the fertilizer investigations of the U. S. Bureau of Soils and chemical engineer with the Utah Potash Co., a company operating on the property of the Florence Mining & Milling Co., Marysvale, Utah, is now in Washington, D. C., where he has taken up consulting work with special reference to fertilizer problems.

Prof. Joseph Daniels, assistant professor of Mining and Metallurgy, University of Washington, at Seattle, Wash., departed from the university as soon as the college year closed, recently for Thane, Alaska, to engage in practical study of mining through work in the Alaska-Gastineau mill, where he will have the opportunity to observe and study the processes of breaking, rolling and concentrating as applied to low-grade gold ore. Mr. Daniels will be away from the University until the middle of September.

Mr. Ralph L. Fuller, vice-president of Harshaw, Fuller & Goodwin, manufacturers of chemicals, was elected president of the Cleveland Chamber of Commerce at its recent annual meeting.

Mr. E. R. Grasselli, second-vice-president and treasurer of the Grasselli Chemical Co., is vice-president of the chamber.

Mr. H. A. Guess has been appointed managing director of the mining department of the American Smelting & Refining Co.

Mr. C. F. Harrington, mechanical engineer formerly with the New York Central Railroad, is now sales engineer with the Powdered Coal Department of the Bonnot Co., Canton, Ohio.

Mr. Maxim L. Kagan, general manager of Franz Krull, Ltd., Reval, Russia, who is here on Government business, has just placed an order with H. L. Barnitz, sales agent of the International Oxygen Co. for a large oxyhydrogen plant of the unit-type generators; the gases produced by this plant to be used for welding and piped throughout their works. Mr. Kagan recently placed orders on refrigerating machinery for the Russian Government aggregating over half a million dollars.

Mr. G. S. Kelley, formerly with the Digger Machinery Co., Inc., has recently been appointed sales representative of the John F. Allen Co. of New York, in connection with the new department they have established for the manufacture of coal-handling and hoisting machinery.

Mr. Isaac H. Levin announces that he has resigned as chief engineer and chemist of the International Oxygen Co. in order to devote his time to chemical research and as a specialist in the electrolytic field. His temporary address is 186 Hillside Ave., Newark, N. J.

Mr. Arthur D. Little, of Boston, Mass., is at present, together with Mr. George Bury, vice-president of the Canadian Pacific Railway, on a trip of inspection through Canada to Vancouver. As was formerly noticed in this journal, Mr. Little and his firm have been retained by Lord Shaughnessy, president of the Canadian Pacific Railway, to assist in carrying out extended plans for a scientific research of Canada's natural resources. Mr. Little's present trip is for the purpose of making a preliminary investigation of the situation and laying out the plans for the future work of his staff.

Mr. H. W. Sparks, sales manager of the Kalbfleisch Corporation, Chattanooga, Tenn., was in New York a short time ago at the office of the Franklin H. Kalbfleisch Co.

Industrial Notes

The Norton Co., Worcester, Mass., has issued a new catalogue describing its grinding wheels and machinery. It is beautifully illustrated and contains much information on alundum and crystolon besides the various products made from them.

Microscopes and Accessories.—The Bausch & Lomb Optical Co., Rochester, N. Y., has issued a new catalogue describing Bausch & Lomb microscopes and accessories. This is the twenty-fourth edition, the first having appeared in 1874. The present catalogue offers the most complete line yet presented. Of especial interest is the new complete series of apochromatic objectives, the first to be offered by an American manufacturer.

Portland Filter.—The Colorado Iron Works Company, Denver, Col., has issued pamphlet No. 28-B, describing the Portland Filter. The description is very complete and includes all the details of construction, together with a list of users of this filter.

Electroplaters Convention.—The 1916 meeting of the American Electroplaters Society will be held in Cleveland, Ohio, from July 6 to 8. It is the intention to spend less time on business meetings and more time on papers and discussions than at previous meetings.

A. H. Ney, Inc., announces that they will continue the business of consulting chemists and chemical engineers, heretofore conducted under the name of A. H. Ney, Ph.D. The new company has been organized to provide increased facilities for its clients in consulting and chemical engineering work, in connection with

the installation of plants for the organic chemical industry. The chief lines embraced will be dyes and intermediates, high explosives, medicinal chemicals and photographic developers.

The Vulcan Soot Cleaner Co., of Du Bois, Pa., state that their New York representatives, the De Ved-Kissick Co., 149 Broadway, New York City, have recently obtained a large order for the type of apparatus manufactured by that company. Vulcan soot cleaners are to be installed on fifty boilers of the B & W type, totaling 30,000 hp. rated capacity, at the Marion plant of the Public Service Electric Co. of New Jersey. In this plant the boilers are set singly with dusting and blow doors on each side, through which a hand steam lance was inserted for hand blowing, these being favorable conditions for soot cleaning by hand as compared to plants where the boilers are set in batteries and have to be cleaned entirely from one side. It was considered more economical, however, to equip the plant with Vulcan soot cleaners. With mechanical soot cleaners the boiler tubes can be kept clean and more efficient in absorbing heat with much less cost for labor.

Common Sense of Export Trade.—In an address before the Executive Club of Chicago, on May 26, Stanley H. Rose, at that time commercial agent of the Bureau of Foreign and Domestic Commerce, but now with the Barber Asphalt Paving Co., discussed some of the important points connected with building up of our export trade. One of the chief difficulties which he mentioned was the lack of young men trained in foreign languages and in export trade and having first-hand experience in foreign countries. Another difficulty is the shortage of American ships. Our export trade is increasing gradually, but we could sell ten times more or perhaps a hundred times more, if we realized the importance of going after the business as soon as possible.

Paul O. Abbé, 30 Broad Street, New York City, has issued Catalogue "B," which includes descriptions of disintegrators, caged mills, crushers, the improved rotary cutter and other apparatus. Considerable space is devoted to the rotary cutter, which is used in a great variety of industries, in the reduction of various materials.

Cellulose in Wood.—The Forest Products Laboratory, Madison, Wis., has perfected a method of determining the chemical constituents of wood. From tests made it has been found that the production of cellulose in modern pulp-making is from 5 to 20 per cent less than the amount in the wood.

The Yaryan Rosin & Turpentine Co. will build a \$250,000 wood pulp plant at Brunswick, Ga. This plant will be operated in connection with the company's distilling plant and will produce Kraft pulp. It is also claimed that a cheap gasoline can be produced from the company's products.

Increased Production of Manganese Ore.—The production of manganese ore in 1915 was 9651 long tons, the largest since 1901 and more than three times the 1914 production, according to the Geological Survey. The imports were 313,985 tons showing the comparative insignificance of our domestic production. Eighty-five per cent of the imports came from Brazil, and about 36,450 tons came from India. None was received from Russia. The production in the United States of manganiferous iron and silver ores was 798,404 tons, which was almost twice the 1914 output. This was mostly used in making high-manganese pig iron, but some was used as a flux by lead smelters and some to make low-grade ferromanganese.

Factory Notes is the title of a monthly pamphlet published by the United States Cartridge Co. of Lowell, Mass. The first number appeared in February, 1916. The Welfare Association of the company has evidently a great deal to do with the issue of this paper. Among its councilors is Mr. H. B. Coho, the widely known former secretary of the New York Section of the American Electrochemical Society. According to the June issue of *Factory Notes* the latest undertaking of Mr. Coho is the formation of a United States Cartridge semi-military company or battalion.

The Improved Equipment Company, New York City, has entered into an agreement with Waldo Brothers, Inc., Boston, Mass., whereby the latter will act as agents in the New England States for coal gas plants, and accessory apparatus designed by the Improved Equipment Company.

Cooling and Cleaning Air for Generators.—The Carrier Air Conditioning Company, Buffalo, N. Y., has issued Bulletin No. 253 describing Carrier cooling and cleaning systems for generator and transformer ventilation. The booklet gives a description of the Carrier air washer and explains the increased power obtained by cooling and washing the air which is used in ventilating a generator.

Association of Chemical Manufacturers formed in Great Britain.—At a meeting of chemical manufacturers held in London on May 23, it was decided to form an Association of Chemical Manufacturers, in order to aid in the building up of the chemical industries in that country, and to help them meet foreign competition after the war. A committee was appointed to prepare plans for the new association.

Poidometers.—The Schaffer Engineering & Equipment Co., Tiffin, Ohio, has issued Bulletin No. 5, describing the Schaffer poidometer with liquid measure attachment for automatic weighing of miscellaneous materials. The liquid measure attachment is a device which delivers a predetermined number of pints per minute in proportion to a predetermined number of pounds of solids on the poidometer, giving a mixture of any desired consistency.

Peat Powder for Railroad Use.—A report has been made concerning the use of peat powder by the Swedish State Railways, according to Commerce Reports. This report discloses the fact that the administration of these railroads has requested the King to propose a bill in the present Riksdag for an appropriation for the erection of a peat-powder factory for their use. The report is as follows:

The investigation concerning the possibility of using peat powder for the locomotives of the State railways has now been finished and the railway directors have placed the results before the King. They have also requested the King to propose a bill in the present Riksdag for an appropriation of 1,300,000 crowns (\$348,400) for the erection of a peat-powder factory at the Hästagen bogs and for the use of enough locomotives for peat powder so that all the trains on the Falköping-Nässjö line may use this fuel.

After a careful examination the railway directors state that they have found peat powder to be very efficient and practical for locomotives, with a fuel value, compared with that of coal, of about 2 to 3. The ratio of peat powder will probably be greater when it has been used and experimented with further. Therefore it is considered a good thing to use peat powder, especially as the country's own resources will be utilized.

In order not to have to depend on private industry and the fluctuations of the market, the directors thought it would be advisable for the railways to have a peat-powder factory of their own, and estimates of the cost of erecting a factory have been given. The Hästagen bogs have been chosen as a suitable place, as it is estimated that 20,000 tons of peat powder can be produced there annually for twenty years. This amount is required by the Falköping-Nässjö line for that period.

Using the ratio given and calculating from the lowest estimate for its production, the cost of peat powder, per ton, would be 15 crowns (\$4.02) and the corresponding price of coal would be 22.50 crowns (\$6.03) per ton. When calculating the price at 15 crowns per ton the items included are: Cost of running the factory, interest on the cost of changing locomotives for the use of peat powder, patent cost, and royalty. The company that erects the factory will charge 25,000 crowns for the use of the patent and 50 ore (\$0.134) per ton of peat powder as royalty.

The 1,300,000 crowns asked for would include the cost of buying the bog and sufficient solid ground, the erection of the factory, patent cost, cost of tracks to the bog, and cost of changing the locomotives.

Book Reviews

Materials of Construction. By G. B. Upton. Octavo (14 x 23 cm.), 327 pages, 181 illustrations; price, \$2.50 net (10/6 net). New York: John Wiley & Sons, Inc.; London: Chapman & Hall, Ltd.

This book covers the structure and properties of the more common materials, being an outgrowth of a laboratory course given by Professor Upton to junior students at Cornell University.

Part I deals with the experimental determination of properties, such as the common mechanical tests, aging, corrosion, rusting, etc. This part is elementary, the discussion being largely based on the internal condition of the material during the test.

Part II discusses the internal properties of materials by metallographic study, and their control by mechanical and heat treatment. It would appear as if this should have preceded Part I, because the phenomena thus determined are made the basis of the analytical treatment of the substance of Part I.

Aside from this, the discussions of Part II, which is really a short study in theoretical and applied metallography, are entirely beyond the field of the usual engineering student; its explanations being in hypotheses of physical chemistry which are doubtful or even dubious, its theories are somewhat overloaded in bearing the weight of the phenomena which they are called on to explain.

Mechanical Technology. By G. F. Charnock. Octavo (13 x 21 cm.), 635 pages, 503 illustrations; price, \$3, net. New York: D. Van Nostrand Company.

The sub-title indicates the field covered as the materials and preparatory processes of the mechanical industries. One-fourth of the contents cover the production and properties of the metals and alloys, another fourth their molding and casting, another various mechanical operations involving their change of shape by forging, stamping, rolling, drawing, spinning, pressing, etc., and there are some minor chapters on timber, stone, abrasives, lubricants, rubber, leather, rope, etc.

The part treating of production and properties is necessarily a brief summary of a very large subject, of very little use to a metallurgist and of little real value to a civil, electrical or mechanical engineer; the foundry section is better; the section on mechanical working is a good summary for metallurgists and chemists, in fact, for them the most valuable part of the book, because of its condensed character.

The metallurgical part is poorly written and its chemistry is weak; the book would be much more useful and reliable if its first 160 pages on production and properties were condensed into, say, 50 pages on properties alone, leaving the student to find production of metals and alloys in books or treatises written by competent metallurgists. The mechanical practice described is mostly English, and does not correspond in many cases to best American practice.

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The New Phase in the Dyestuff Tariff Fight before Congress

A new dyestuff tariff bill has been placed before Congress, together with the general revenue bill of the Administration. The dyestuff tariff fight has thereby entered into a decidedly new phase.

That almost certainly a new dyestuff tariff will be enacted by the present Congress means two very important things. First, that everybody in Congress agrees that it is a vital necessity for the American nation to be self-contained with respect to the dyestuff and allied industries. Second, that everybody in Congress now agrees (and this has never happened before) that the creation and the sound development of a general dyestuff industry is impossible without a protective tariff sufficiently high to give real protection and not merely yield revenue.

This is, in fact, a big achievement and full credit must be given to the Administration and to Congress for having agreed on the principle. It is clear proof of an earnest desire of the Administration and of Congress to deal with the chemical industries with that degree of fairness of consideration to which the chemical industries are entitled in view of their fundamental importance for the nation, but which has not always been accorded them in the past.

As an agreement has now been reached on the principle, it should not be difficult to discuss the remaining differences intelligently without excitement. The present situation may be summed up as follows: All agree that the present Underwood tariff is insufficient. But the representatives of the chemical industries insist that the rates of the Hill tariff bill represent the minimum necessary for real protection, while the Kitchen tariff bill now before Congress grants less.

One decidedly novel feature of the Kitchen bill (which is given in detail on page 65 of this issue) is that it sets a time limit on the surtax. As it is an infant industry that is to be protected no one can object to the fairness of the principle of the time limit. The question of how long a new industry is an infant and needs protection, remains open. But as this is a matter which can be adjusted or corrected in the future, we may dismiss this fundamentally most interesting feature of the Kitchen bill from our present discussion.

There remain two important differences between the Kitchen bill and the Hill bill and these deserve immediate attention. The first relates to the amount of protection. As the detailed differences between the rates of the Underwood, Kitchen and Hill bills are given on page 65, it will be best here to bring out these differences by another rather instructive method for which

we are indebted to Dr. B. C. Hesse, one of the foremost authorities on the subject. Dr. Hesse bases his discussion on the amount of importations of dyestuffs and intermediates into this country in 1913. The duty on these according to the Underwood tariff is \$2,298,632, while it would be \$4,999,084 for the Kitchin bill, and \$6,908,648 for the Hill bill. In other words, where Underwood grants \$1.00 protection, Kitchin proposes a protection of \$2.18, Hill of \$3.00. (Of course, with a different proportion of the importations of aniline dyes, of alizarine and anthrazene dyes and indigo, and of intermediates, the proportion indicating the relative protection afforded by the Underwood, Kitchin and Hill tariffs respectively would be somewhat different from 1 to 2.18 to 3, but these are the best figures available.)

Now what does this really mean? This country wants to add a new industry to its national household. Is it wise to haggle and try to do for \$2.18 what all experts agree costs \$3.00 if it is to be done right? If an individual house owner wants an addition made to his house and on expert advice finds it will cost him \$3,000 to have it done right, he would certainly hesitate a long time before trying to find somebody who would agree to do something for \$2,180. If he is wise he will decide to have it done for \$3,000 if it is to be done at all. Can the American nation afford to be less judicious if it really wants an American dyestuff industry?

The second important difference is that the Hill bill tries to protect the industry all around, the Kitchin bill does not, as it exempts alizarin and anthracene dyes and indigo from the surtax. We cannot do better than quote Dr. B. C. Hesse's comment on this feature: "If you were building a high board fence around your vegetable garden to keep your neighbor's chickens out would you build three-fourths of the fence so that it went well into the ground, and leave the other one-fourth 3 ft. from the ground on the theory that the chickens would not find this weak spot in your fence? In exempting anthracene, alizarin and indigo dyes and indigo from the surtax, that is precisely the theory on which the Kitchin bill proceeds, and it offers, at the suspended portion of the fence an added bait for the chickens, by threatening to remove the surtax unless 60 per cent of the value of our total consumption is produced in this country within five years. This is about the same as if, in addition to building the fence as just described, you industriously sprinkled a lot of 'chicken feed' so that it leads directly to this hole in your fence. This is the strategy of the Kitchin bill."

A wonderful beginning has been made by American dyestuff manufacturers during the past few years. To accomplish more—to accomplish all that this nation has a right to wish for—they now need the support of the nation as represented by Congress. And Congress has made a wonderful beginning by grasping correctly the principal point of the situation.

Having shown a broad attitude of mind in the matter of principle, Congress can hardly afford to spoil its work by narrowness in fundamentally important details. We sincerely hope that the provisions of the Hill bill will be enacted into law.

Increased By-Product Coking

No criticism can be made of the rate at which the iron industry is now adopting the by-product coking process. In the earlier years the progress was slow. It was not until 1900 that an output of a million tons of by-product coke was attained and ten years later the output was only 7,138,734 tons. Last year the output was 14,072,895 tons, representing a doubling in five years, a fairly good record, but not a very good one, considering the great promises of profit. In the earlier years, however, the iron industry had to finance its by-product oven construction largely out of profits, and frequently these were not large.

Of late financial machinery has been available whereby such new construction could be much more readily undertaken.

With an output during last year of 14,000,080 tons, the capacity available at the close of the year may be estimated at considerably more. Several batteries of ovens have since been completed and much construction work is in progress, the present program indicating that new plants, of from say 50 to 200 ovens, are to be completed at an average of about two per month during the next six or nine months. The by-product coking capacity a twelvemonth hence will probably be close to 25,000,000 tons, representing between 40 and 45 per cent of the prospective coke requirements of the country, which may be estimated at not far from 55,000,000 tons.

Necessarily a great many beehive ovens must be abandoned, for the increase in the production of by-product coke is very greatly in excess of the increase in consumptive requirements. The production of beehive coke, indeed, reached its maximum as long ago as in 1907, and the decreases since then have not been due entirely to ovens being abandoned because the coal over which they had been located was worked out. The condition of forced abandonment of beehive ovens makes it that the coal remaining becomes available and there is less search for new and cheap coal for by-product use than was expected. Connellsville and Pocahontas coals are already being shipped in a large way to by-product ovens. In many instances, indeed, the by-product ovens are built by furnace interests having beehive coking operations, the beehive ovens being simply abandoned and the coal shipped to the new ovens, to be used perhaps in conjunction with smaller proportions of coal from other districts.

By far the major part of the by-product coking now being done or in prospect involves the recovery of little of the by-products apart from the gas, and it is evident that when by far the major part of the coke is being made by the by-product process there will still be a great deal of work to be done by way of installing the adjunct processes for various recoveries of the other valuable products.

Dirty Oils

Oils are delicate bodies, complex in composition, and those of vegetable or animal origin are very likely to decay if they are not properly treated. It is not con-

sidered good form to let a dead pig lie around until it becomes a nuisance and then proceed to secure the lard from it. But many oils which are as complex in their constitution and as subject to decay as lard are handled in such a manner that no plant or animal could live and contain them in the condition that they are brought upon the market. It is safe to say that millions of dollars are annually lost in the United States on oils that were originally good and that could have been kept good, but have gone bad. Oils should be refined as soon as possible after they are pressed because organic oils have a way of increasing like rabbits, once they get started, and while the cottonseed oil industry, with its problems of transportation and the signal chemical talent engaged in it may well be allowed to take care of its affairs without gratuitous criticism, there are other oils that come to market in a condition that calls for a little investigation as to their sources and then a little admonition and wholesome advice to their producers.

The tropics sometimes seem hopeless. Some presses lately sent down and set up at a convenient tropical station were not operated on the ground that they were too heavy for women and children to work them. A little civilization is creeping in and it occasionally shows in the oils; but civilization grows delicate when it reaches the tropics and care must be taken that it does not grow thin from loss of temper.

Peanut oil, coming from France, is much better prepared than any domestic product—or at all events the most of our domestic product—and there is no reason for this at all. When peanuts are pressed in their husks, in an old cottonseed press that has not been cleaned out, it indicates a looseness of method that should be corrected. There's no use in letting things get down at the heel that way. When we consider what careful treatment oils need the time seems ripe for calling for better factory practice in their preparation. A great deal of trouble will be avoided if more attention is paid to this first step in the industry.

Blast Furnace Performance

The blast furnaces of the United States have disclosed quite accurately in the past six months what they can do. There have been only minor variations in the rate of output, and these are attributable largely to weather conditions. There were increases in February and March and a further increase in May, while production fell off a trifle in June. The performance seems to have been quite in line with conditions as to humidity in the atmosphere, and as both the steel interests and the merchant furnaces have been striving for maximum output the actual production seems to be an accurate index to the average commercial capacity. This may be taken at an average of 39,500,000 to 40,000,000 tons for a twelvemonth, with its periodic variations in weather conditions.

It is commonly said in the iron industry that after a period of relative inactivity the furnaces are found to be in good physical condition, all nicely relined, etc.,

whereby they can stand a strong campaign for a time, but that after such a campaign so many must go out for relining that the production is then reduced. There has been no case in actual practice of this theory being substantiated. Production declines only when the weather becomes unfavorable or the demand for iron decreases, and sometimes in the latter case it does not decrease altogether as promptly as it should. There is no reason to believe that the existing furnaces could not make close to 40,000,000 tons of pig iron in the twelve-month from date.

One new blast furnace was completed and blown in May 13 and another on June 5, while nine stacks are now in course of construction, their average date of completion being perhaps about six months hence, while all the new stacks should be completed within a twelvemonth, if market conditions continue such that rapid construction work is desirable. The country's commercial capacity may then be taken at about 41,500,000 tons a year.

Only a qualified statement as to capacity, however, can be made, as commercial conditions vary. At the present time an unusually large amount of spiegeleisen and ferromanganese is being made, the tonnage output being counted simply as "pig iron," whereas the output per stack is much less than if real pig iron were being made. One does not know whether the furnaces will make more or less of the manganese alloys in future, that being a matter of commerce, not of physical capacity.

Again, in the whole history of the blast-furnace industry there have been furnaces falling by the wayside. They are not kept up to date physically, or conditions change as to supplies of raw material. They are not abandoned immediately upon their last blast, as the owners are disposed to wait for something to turn up. Under exceptional market conditions, with high-priced pig iron and relatively low-priced raw materials a furnace supposedly out of the running may become active, while in reverse conditions a furnace supposedly fit may have to be counted out. Thus the commercial capacity of the country really varies by a complicated formula, in which there are factors of demand, market prices of pig iron and raw materials, wage rates and other items. What is called "demand" is a separate factor, for there have been times when the going market price appeared sufficient to bring an idle stack into blast, but it was impossible to sell sufficient tonnage at the price to justify incurring the lump sum expense of blowing in the stack. Thus one can hardly say more than that under present commercial conditions the actual blast furnace capacity is in the neighborhood of 39,500,000 to 40,000,000 tons, and is destined to become 41,000,000 to 42,000,000 tons within a twelvemonth. The existing capacity proves to be larger by several million tons than was estimated before the furnaces were subjected to their present test. As a rule the individual outputs have exceeded previous outputs and sometimes they have surprised the managers themselves.

Readers' Views and Comments

Liquid Jets

To the Editor of Metallurgical & Chemical Engineering

SIR:—In your issue of June 15 I read with interest the comments of Mr. B. DuFaur upon the article of Mr. C. Terry Durell regarding liquid jets, which appeared in your issue of March 1 last.

Mr. DuFaur states that the liquid jet was used in Australia as early as 1908. It is quite well known that it was used in America some years before that time for the purpose of efficiently commingling a liquid and gas under pressure.

During the year 1903 I used the liquid jet as a fume arrester. The entire arrangement consisted of a 2-in. centrifugal pump, a small tank, a nozzle and its housing, and the necessary piping to connect all into a continuous circuit. The nozzle with its housing appeared as a very large filter pump and patterned after the one commonly used in the laboratory.

When the entire arrangement was to be placed in operation, the tank was filled with the liquid and the centrifugal pump started, it being supplied by the liquid in the tank. The liquid was thus forced by the pump through the nozzle and then delivered to the tank with its burden of commingled gas. The liquid was then taken up by the centrifugal pump again, and thus continuously circulated.

About the time mentioned above or shortly thereafter I applied for a U. S. patent covering the arrangement as a fume arrester. The patent was allowed but I never took it out. I learned through the patent office that practically the same thing had been patented some years before for the purpose of purifying illuminating gas.

During the year 1905 I conducted experiments upon a much larger scale at the property of a mining and smelting company of Utah. In these experiments I used a 10-in. centrifugal pump but the cost of pumping was excessive. Under the most favorable conditions the amount of free cold gas drawn into my apparatus approached one volume for every volume of liquid passed through the nozzle.

This method was used by me quite frequently to aerate cyanide solutions, and during the last few years I have made numerous flotation experiments by use of the method with varying degrees of success.

HENRY R. ELLIS.

Salt Lake City, Utah.

Buttering Wages

To the Editor of Metallurgical & Chemical Engineering

SIR:—Far be it from me to urge the love of money upon people. The general impression prevails that we have enough of that sort of thing in this country, and I have no desire to contradict it. But when I consider the habits of life that prevail in many places, which are too low to entertain thrift, I begin to doubt the old saw that the love of money is the root of all evil.

There is a great deal of work to be done in this world and most of us need an incentive of some kind to induce us to lend a hand. This applies to all of us: masses, classes, member of manufacturers' associations, boards of trade and the I. W. W. It is also worthy of note that the art of getting work done seems to involve something more than the payment of wages. It appears that wages need to be buttered in some way to make them acceptable, and to neutralize their bad

effects. Let us consider a few examples from fact and fiction in which it is indicated that high wages may fail to pay.

I once had a skilled workman in my employ, in charge of a kettle. The man received \$2 a day. He was a good man, intelligent, industrious and willing. He then received authority over three kettles and two helpers, his pay being increased to \$2.50 a day. In time he achieved supervision over all the kettles; his wages were \$3 a day, and I was relieved of the constant agony of watching the kettles and the fear that some careless laborer might waste several hundred dollars worth of material.

Close at hand was another operation that needed occasional watching. This was a much lighter task, but attention was important. The foreman was sure he could look after it with ease. Subsequent events proved that he could, and for this he received 25 cents more per day, making in all \$3.25. There seemed to be some devilment in that last quarter. The foreman grew pompous and vain, he bullied the men under him until the best ones left, he conceived the idea that he should be made an elder in the church, and he caused so much trouble in the community that he had to be laid off for a while. There was something wrong in that last quarter; the employer lacked wisdom by not buttering it properly.

In a late number of *Punch* there is depicted a washerwoman who tells her mistress that she cannot continue to wash for her because her man has employment and is earning so much that the last week they had been obliged to put some of their earnings in the bank, and if they did not look out they would be compelled to do the same thing again. This is probably taken from fancy, but it is not an impossibility, as we shall see. The psychological problem is simpler in this case; what the woman and the husband lacked was a knowledge and understanding of the art of administering funds.

Now comes a report of Mr. Richard I. Austin, the Federal Reserve Agent of the Philadelphia district, in regard to the business situation with special reference to the attitude of labor. Mr. Austin says:

"There is universal complaint that as wages are increased a large class of wage-earners become less productive, and the failure of industrial plants to make sufficient or reasonable output is preventing the realization of much, if any profit from operations. The attitude of wage-earners is disappointing. Instead of taking advantage of the present wonderful opportunity to make large earnings, they are apparently not netting much more than formerly, when wages were much lower; the cost of living for them, as for others, is much higher, and the whole country is suffering a great economic loss through the failure of our industrial establishments to produce the volume of goods for which there is at present so great a demand."

There we have it. The week's work is cut down to five days and even less, and because labor is scarce the competent members of the force let down in speed and efficiency. Now there is no use in saying that they are a pack of fools, because they are not. The fact is they are started wrong, their leading is bad, and their philosophy is contrary to what the rest of us believe in public welfare. If laborers were to engage in habits of thrift they would be in a position to make better bargains for themselves when times are hard, because

they would not be under the drive of need to take any work at any wages when both are scarce. They still could bargain and show the value of competent workers over the incompetent ones; they could prove their point and get work, because employers are always out for profits, and they want steady hands.

The argument that has won against this is that of collectivism, in which it is held that they who labor are a class by themselves, the competents and incompetents together, and that whatever will injure the owners of the work is of just that measure of advantage to labor. This is not true, because unless labor keeps in form and keyed up to capacity it can neither administer affairs nor work for itself. Capital selects its instruments with care and drops out sloths, incompetents, booze-lifters and dull-wits to shift for themselves. Capital is selective while labor is collective, and while this does not prevent the two from fighting or hinder labor from running capital, it does prevent labor from winning. Without the discipline of efficiency, speed, thrift and independent thinking, those who are weak of will drift over from competence to incompetence, and a gradual degeneration of labor and production takes place. Labor can do nothing with that incubus.

Why, then, have misleading arguments and a false philosophy gained such headway among laborers? It is not because of the stupidity of laborers. It is because the arguments have been presented to them with greater conviction and superior ability than the arguments for industry and thrift which employers claim to preach. The arguments of the employers have been feeble and without enough interest to make them carry. Labor can come into its own, the productiveness of this country can be increased beyond the dreams of to-day, and the feeble of mind, body, and will can be employed at least so that they support themselves, if only labor will avail itself of that worldly wisdom, without which goodness itself is likely to fail. The stupidest thing on earth is to fight windmills. Next in order of stupidity is the cultivation and development of habits of inertia—of laziness. These two things will kill progress anywhere and any time.

I lately read a letter from a man in prison approaching the end of a long sentence at hard labor. "No matter how you feel," he wrote, "You can't get even with the State or with Society, which has turned you down, by shirking work. My companions call me all sorts of a fool for being a willing worker, but I don't mind that because in this very thing lies my only hope. If I let myself get into the condition in which sustained and hard work is impossible to me—and nothing is easier—then I shall be no good when I get out. And I don't want to come back here a little bit. That is the trouble with the bums here; they can't work more than a few days in succession no matter how hard they try. They are sure to come back."

PETER TEN BROECK.

New York City

Coming Meetings and Events

American Institute of Metals and American Foundrymen's Association, Foundrymen's Convention, Cleveland, Sept. 11-16.

American Institute of Mining Engineers, Arizona, Sept. 18-23.

Mining and Metallurgical Society of America, New York Section, New York, Sept. 21.

Second National Exposition of Chemical Industries, New York, Sept. 25-30.

American Chemical Society, New York, Sept. 25-30.

American Electrochemical Society, New York, Sept. 28-30.

American Society for Testing Materials

An account of the first day's meeting, excepting part of the evening program, of the American Society for Testing Materials' meeting held at Atlantic City, June 27 to 30, was given in our issue of July 1.

Following the presidential address on Tuesday evening an exceedingly interesting paper on the "Hardening and Tempering of Eutectoid Carbon Steel and on the Shore Test," by HENRY M. HOWE and ARTHUR G. LEVY, was presented by Professor HOWE. A paper entitled "Experiments on the Plastic Elongation of Wires" was read by A. V. DE FOREST. This paper contained a description of a sensitive apparatus for observing the "creep" or slow stretch of wire under load, and recording the stress deformation diagram on photographic paper. The paper was discussed by Professor HOWE.

The report of Committee D-1 on "Preservative Coatings for Structural Materials" was read by P. H. WALKER, chairman, and a paper on the "Acceptability of Linseed Oil" was read by C. D. HOLLEY. This paper, which was a discussion on the question of "foots" in linseed oil, elicited further discussion from Messrs. G. H. PICKARD and H. A. GARDNER. Mr. PICKARD, who is a member of the linseed oil committee, said that the committee had been working on the question of how much foots was allowable, but that the laboratory in which the work was being done had been destroyed by fire. Mr. GARDNER cited a case in which the moisture in the foots of a high-foots linseed oil had prevented the paint from drying.

The Wednesday morning meeting was devoted to iron and steel. Professor HOWE, who presided, introduced Prof. A. L. VAN HECKE of the University of Louvain, Belgium, who made a few remarks and expressed his pleasure at being able to attend the meeting. Professor VAN HECKE is studying the latest developments in iron and steel in this country.

Four reports were read of committees A-1, A-4, A-5 and A-6, on "Steel" in general, "Heat Treatment," "Corrosion," and "Magnetic Properties," respectively. These reports were read by Messrs. C. D. YOUNG, ALBERT SAUVEUR, S. S. VOORHEES and C. W. BURROWS, respectively.

A paper was presented on "National Standard Specifications and Their Relation to Export Trade," by W. R. WEBSTER.

A paper on "Heat Treatment of Carbon Steel Locomotive Axles," by C. D. YOUNG, brought out considerable discussion as to the advisability of water quenching instead of oil quenching. The paper discussed results obtained with heat treatment of axles, using oil quenching in one case and water quenching in another. The results were favorable to water quenching.

A paper on "Recrystallization as a Factor in the Failure of Boiler Tubes" was presented by A. E. WHITE and H. F. WOOD. This was the result of an extensive and interesting piece of research work and is reserved for publication in a later issue.

Wednesday afternoon was devoted to recreation, and some of the members journeyed to the Northfield Country Club, where a golf tournament among the members of the society was in progress, and some of the sailing enthusiasts enjoyed this form of sport.

The Wednesday evening session was devoted to Tests and Testing. The report of committee E-1 on "Methods of Testing" was read by G. LANZA, chairman. A topical discussion on yield point and proportional limit was presented by J. E. HOWARD, T. D. LYNCH, H. F. MOORE and F. B. SEELY. It was agreed that the term elastic limit was better to use than proportional limit, and that the term yield point was vague and inexact. Curves

were shown of various steels showing a variety of ranges between the proportional limit and yield point, and it was urged that designers specify steel whose load would always fall well below the proportional limit.

Other papers presented were as follows: "An Apparatus for Determining Soil Pressure," by A. T. GOLDBECK and E. B. SMITH; "Endurance and Impact Tests of Metals," by D. J. MCADAM, Jr.; "Constants and Diagrams for Repeated Stress Calculations," by H. F. MOORE and F. B. SEELY; "Methods of Testing the Durability of Pipe Under Corrosion," by F. N. SPELLER. This paper is published in full on page 87 of this issue.

At this session a resolution was passed indorsing legislation to enforce the use of the Centigrade scale in Government publications after 1920. This is the first time the Society has acted on a legislative question.

The Thursday morning session was devoted to ceramics, road materials, and gypsum. The papers consisted mostly of committee reports.

A paper on "Practical Methods for Testing Refractory Fire Brick" was presented by C. E. NESBITT and M. E. BELL. In discussing this paper J. S. UNGER said it showed the importance of tests for bricks. The suggestion that tests be made more severe than actual working conditions in order to accelerate the tests is a radical departure from accepted practice. Failure of bricks is not due to one cause, but to a combination of several causes. Dr. Unger did not think that the rapid water-cooling used in the tests was comparable to air-cooling in practice. The results showed that some bricks are different at one end than at the other, and therefore show a non-uniformity of material. The most important parts of the paper are the curves showing the effect of water in making brick and the table showing the pressure effect. G. C. STONE confirmed the contention that denser brick was the better to use. He found that in testing brick it was impossible to get good slagging results except in actual practice. W. H. FULWEILER said the authors were to be congratulated for having the courage to break away from ordinary testing methods. He thought the results of using a ball as pressure medium against brick might not give the same results as a load spread over the whole brick. In tests made by him the removal of the outer skin caused irregularity in the results. R. C. PURDY said that he had found no laboratory test comparable to service tests. Publication in full of this paper is reserved for a later issue.

A smoker was held Thursday evening, at which a general good time was had.

The Friday morning session was devoted to non-ferrous metals. The report of Committee B-1 on "Copper Wire" was read by J. A. CAPP, chairman, and of Committee B-2 on "Non-Ferrous Metals and Alloys" was read by WILLIAM CAMPBELL, chairman. A paper on "Aluminum Bronze" was presented by W. M. CORSE and G. F. COMSTOCK. A paper on "Specifications for Brass Condenser Tubes" was presented by A. E. WHITE.

The Friday afternoon session was devoted to miscellaneous materials. The report of Committee A-3 on "Cast Iron and Finished Castings" and Committee D-6 on "Coke" were read by RICHARD MOLDENKE, chairman; the report of Committee D-7 on "Timber" was read by HERMANN VON SCHRENK, chairman. The following papers were presented: "Apparatus for Testing the Standard Cast-Iron Arbitration Bar," by H. L. MORSE; "Quantitative Test for Resistance of Lubricating Oils to Emulsification," by W. H. HERSCHEL; "Emulsification of Mineral Lubricating Oils," by P. H. CONRADSON.

The total registration was between 500 and 600, exclusive of about 150 ladies, for whom special features of entertainment were provided.

The Iron and Steel Market

The extreme dullness in the steel market has served to emphasize its underlying strength, for absolutely no selling pressure has been developed by the dullness, the mills all holding strictly to their former prices, while they do not offer materially earlier deliveries than they did a month ago. Instead of the market becoming dull at the beginning of July, as it usually does, it turned dull about the beginning of June, and thus a fair test has been afforded.

The mill position as to actual orders in hand makes a very strong showing. The United States Steel Corporation is stated to have 6,000,000 tons of actual shipping orders in hand, in a total of about 10,000,000 tons of unfilled obligations, showing not only a very large tonnage but a very high proportion of obligations in the form of specifications. The other large interests are assumed to be in substantially the same position.

The disclosure of such a strong mill position has caused sentiment to become much more hopeful as to the more distant future of the steel market. Hitherto the general opinion has been that the course of the market would be simply one of the orders in hand being filled, together with such orders as drift in from time to time when there is no general buying movement, and that thereafter there would be a general readjustment, with a period of lessened mill activity and a reduction in prices. Now, however, the expectation is entertained in some quarters that next fall another buying movement will be inaugurated, without any readjustment in prices, whereby the period of full activity would be prolonged well into 1917 at least. This would be an unprecedented course, for hitherto no general buying movement in steel has started at the price level at which the preceding movement left off, it being conventional for prices to decline between buying movements, but, of course, all conditions are abnormal at this time.

Export Demand

The demand for shells and shell-steel, instead of being satisfied by the recent heavy buying, has continued to date, France and Italy being now in the market in a large way, and for deliveries through the first quarter of the new year. Various reports have been given circulation, chiefly in stock market circles, that munition business is declining, but these reports are not confirmed in steel circles and appear to have been promulgated for an ulterior purpose. Indications are that the production of shell steel will be greater in the second half of the year than in the first half.

The demand from the allied belligerents for classes of steel incident to the prosecution of war, other than shell steel, is very insistent, covering railroad material of all descriptions as well as ship steel. Many weeks ago Russia inquired for 350,000 tons of rails, and shortly placed somewhat more than half the tonnage with the Steel Corporation, but great difficulty has been experienced in arranging deliveries with the independents for the remainder. Bessemer steel rails have been offered, but apparently have not been accepted as yet. Russia is also inquiring in a large way for cars and locomotives.

The demand from neutral countries for steel products has continued heavy since the increase two or three months ago, and it seems probable that in the event of a decrease in domestic consumption the export business would readily take up the slack.

Finished steel prices are unchanged for forward delivery and no material change is expected for months in the important products. There has been a further diminution in the premiums asked for early deliveries of certain classes of material, and it is probable that

before long all premiums will have disappeared except on plates. The position in plates is a remarkable one, seeing that the regular mill price of 2.90c. is \$8 a ton above the regular price on shapes and bars, yet for early deliveries of plates a premium above 2.90c. regularly obtains.

Pig Iron

The condition noted in last report as to southern warrantors has been largely relieved, the warrantors that speculators were offering on the market at large cuts from the furnace price having been absorbed in major part. The furnace price has declined 50 cents to \$14, Birmingham, for early deliveries and the warrant market is on approximately the same basis. The northern markets have been decidedly quiet and some have shown a slight tendency toward weakness. The statistical position of pig iron is better than ever. There was a slight decrease in production in June, doubtless due to higher humidity, and the production in June, July and August promises to average less than in the preceding months, whereas the requirements of steel works promise to average more, as new steel making units are being completed from time to time and there is ample business to keep all capacity engaged. The scrap market, which had declined for three months and was exercising an unfavorable sentimental effect upon pig iron, suddenly turned strong the closing days of June and has since been advancing. Heavy melting steel has brought as high as \$17.25, delivered Pittsburgh, when a fortnight earlier it was difficult to sell at \$15.50. We quote: No. 2 foundry iron, delivered Philadelphia, \$19.75 to \$20.25; f.o.b. furnace, Buffalo, \$18.50 to \$19; f.o.b. furnace, Chicago, \$19; f.o.b. Birmingham, \$14 to \$14.50; f.o.b. Valley furnaces, 95 cents higher delivered Pittsburgh; Bessemer, \$21 to \$21.50; basic, \$18 to \$18.25; foundry and malleable, \$18.25 to \$18.50; forge, \$18 to \$18.25. Ferromanganese is much easier, prompt being frequently offered at as low as \$200, while there are reports of occasional concessions, for late 1917 delivery, from the regular contract price of \$175.

Steel

The billet market reflects great strength in the mill position. There is a heavy demand for export steel, as export demand goes, but a very light demand for domestic consumption, and that only for the earliest delivery, and the total demand is thus far from large, yet mills are very stiff in their views, frequently refusing to quote at all. Soft open-hearth steel is usually quoted at \$45, slight concessions from this price being made occasionally. Bessemer is nominally about \$43, but as a matter of fact demand for Bessemer is so light that no definite market is developed and any considerable demand might find the mills unable to quote. Discard and rejected steel, arising in the manufacture of shell steel, is less of a factor in the market, not because there is less of it but because the mills have found the market can absorb only so much of such special steel, and what they can sell they are selling in more orderly fashion, no matter how much may be left to be disposed of later, by sale as merchantable steel or by consumption as scrap.

The Non-Ferrous Metal Market

Monday, July 10.—The non-ferrous metals have continued generally dull during the last two weeks. The trust price of lead was reduced \$10 per ton, which was rather unexpected. Spelter continues its weakness.

Copper.—Copper has held fairly steady for a long time in spite of continued dullness. This has been due to the sold up condition of the market. Last week

some recessions were made, although declines were very slight. Producers ask 26c. to 27c. for fourth quarter electrolytic. Second hands offer prices slightly lower. For earlier deliveries prices ranging from 26c to 28c. are asked. The production in June is estimated at 200,000,000 lb., the exports amounting to 40,000 tons. According to estimates, the exports in the first half of the year were 145,000 tons, which is 7000 tons greater than the same period in 1915.

Tin.—Spot tin has been easy on heavy offerings, and is now quoted at about 39 $\frac{1}{2}$ c. The deliveries to consumers in June were 6398 tons, which is a record-breaking amount. Futures remain very firm, and there is only a difference of $\frac{3}{4}$ c. between spot and December deliveries. Straits tin for July delivery is quoted at 39c. with August at 38 $\frac{3}{4}$ c., September at 38 $\frac{1}{2}$ c., October at 38 $\frac{1}{2}$ c., and November at 38 $\frac{3}{8}$ c.

Lead.—The American Smelting & Refining Company reduced its price of lead to 6.50c., New York, on July 5. It was not expected, as business in lead was improving. This reduction has unsettled the market, and consumers are not buying to any extent. Independents also reduced their price to 6.45c., New York, following the trust reduction. Foreign and domestic buying was good up to July 5, considerable lead going to Russia and England.

Spelter.—Spelter continues to decline on further weakness and dropped below 10c. last week, for the first time since April of last year. Futures are stronger, and third quarter is quoted at 9c. and fourth quarter at 8c. The London spot market has also declined, and this has further depressed our market.

Other Metals.—Antimony has not touched bottom yet, and is offered at from 16c. to 17c. The market is weak and dull. Aluminum has declined slightly, and is now quoted at 60c. to 62c. Quicksilver is offered at \$80 per flask, with platinum at \$80 per oz. Silver is quoted at 62c.

Presentation of the Franklin Medal to Theodore W. Richards

At a meeting of the Franklin Institute of Philadelphia, held on May 17, 1916, the Franklin Medal was presented to Dr. THEODORE W. RICHARDS, professor of chemistry at Harvard University, and to Dr. JOHN J. CARTY, chief engineer of the American Telephone and Telegraph Company, while the Elliott Cresson Medal was presented to the American Telephone and Telegraph Company, THEODORE N. VAIL, president.

Dr. HARRY F. KELLER, for the Committee on Science and Arts of the Franklin Institute, made the presentation speeches. He pointed out that accordance to the wishes of the founder, Samuel Insull, the Franklin Medal is "awarded from time to time to those workers in physical science and technology, without regard of country, whose efforts, in the opinion of the Institute, have done most to advance our knowledge of physical science and its applications."

In reviewing Dr. Theodore W. Richards' work, Dr. Keller spoke in part* as follows:

In spite of the vast expenditures for their armies and navies in times of peace, the governments of European countries have long realized that liberal appropriations to their institutions of learning and for the promotion of scientific research is money well invested; in our country, on the other hand, the endowment of universities and research laboratories is largely dependent upon the munificence of private individuals. Nevertheless, the advancement of science in American laboratories, and by American workers, especially in recent years, has been quite abreast of that

*The complete report of all speeches may be found in the July issue of the *Journal of the Franklin Institute*, pages 6 to 14, from which this account is taken.

in European countries; and in not a few branches of science we are proud to point to our compatriots as the peers of those abroad.

The eminent chemist who is to receive the Franklin Medal is a striking case in point. Though still in the prime of life, and looking forward, perhaps, to even greater achievements, his contributions to chemical science are universally recognized as second to none, either in number or importance, made by any contemporary investigator. Only recently the Nobel Prize of 1914 in chemistry was awarded to him, and the oldest and most famous institutions of learning in every part of the world have fairly showered upon him their highest honors and distinctions. More than a dozen universities have conferred upon him their honorary degrees; learned societies, both here and abroad, have vied with one another in electing him a member or officer; and the most highly prized trophies of chemistry, such as the Davy, the Faraday, and the Willard Gibbs Medals, have been bestowed upon him. With the award of the Franklin Medal the last great link in this great chain of honors would seem to be added.

And it seems peculiarly appropriate that this should be done in his native city. He was born in Germantown, in



THEO. W. RICHARDS

1868, the son of a well-known painter of landscapes and marines. It was there, also, that he spent most of his childhood, and where his gifted mother conducted his early education. His curiosity and interest in experimentation and science were early awakened by friends of the family, among them Dr. John Marshall of the University of Pennsylvania. At the age of fifteen he entered the Sophomore class at Haverford College, where he first seriously studied chemistry under Dr. Lyman B. Hall. After graduation in 1885, he studied Greek and entered the Senior class in Harvard, as its youngest member, in the autumn of the same year.

Since then his career, with the exception of a few and comparatively short interruptions, has had its scene in Harvard University. Graduating as A. B. in 1886, *summa cum laude*, with highest honors in chemistry, he received a fellowship in the graduate department and conducted research work under Josiah Parsons Cooke, taking the degrees of A.M. and Ph.D. in 1888. The following year he spent in Europe, visiting eminent chemists and important laboratories in various countries, and familiarizing himself with special methods of analysis and research. Returning to Harvard in 1889, he was appointed assistant, and from this position he gradually rose to that of Professor of Chemistry and Director of the recently founded Wolcott Gibbs Memorial Laboratory.

The only prolonged absences from Harvard were for the purpose of studying with some of the German masters, and, in 1907, when he was selected as Visiting Professor to the University of Berlin. Teaching a group of advanced students his methods of experimentation and research, he made a profound impression on both the students and professors. It was little short of a revelation to the German chemists that the time had arrived for reciprocity between the American and German universities in the teaching of the most advanced thought and practice in chemical research.

To sketch and characterize the work of our metallist in a few sentences—and that is all I can here attempt to do—is a difficult, an almost hopeless, task. If you consider

that ever since he graduated from Harvard in 1886 he has continuously and indefatigably been active as a teacher and investigator; that his fertile brain has planned and directed the work of great numbers of assistants and students; that his contributions to science extend over vast domains of inorganic, physical, analytical, and theoretical chemistry, and in many cases far beyond the border-line of physics; if you consider how numerous, divergent, and extended are the paths he has traveled, you will understand that only a very few of the high lights can here be pointed out.

Best known and, in certain respects, most important, are the researches on the atomic weights of more than twenty of the chemical elements. These elements were not chosen at random, but very carefully selected with a view to solve chemical problems of fundamental importance. The papers published on this work extended over many years, and must be counted among the classics of chemical literature. They reveal the masterly reasoning of the author, his fertile scientific imagination, his resourcefulness and skill as an experimenter. They abound in the description of new observations, new methods, and new forms of apparatus. The atomic weights themselves are determined with the utmost precision that the resources of modern science permit.

It was from the investigation of the fundamental properties of the elements that most of his other researches took their starting-points. Among them are the studies of the compressibility of elements and compounds; of the changes in atomic volume; of the birth of crystals as revealed by micro-photography and the kinetoscope; of thermochemical, electrochemical, and, lately, also of radiochemical problems. His hypotheses concerning the sour taste of acids and the compressibility of atoms are noteworthy contributions to theoretical chemistry, and he has also devised one of the best methods of teaching elementary chemistry.

As, due to illness, Dr. Richards was unable to be present, the president announced that the medal and accompanying certificate would be forwarded to him. Dr. George A. Hoadley then read the following address for Professor Richards:

The Essential Attributes of the Elements

BY THEODORE W. RICHARDS

We come together to-day, in this world-renowned Institute, founded in honor of one of the greatest of our countrymen, to participate in an annual celebration of progress in pure and applied science. Franklin himself would have heartily approved of such an annual celebration; he was deeply interested in the study of Nature, and profoundly convinced of the importance to humanity of exact knowledge and its practical application. Inspired by his conviction of the usefulness of science, he founded here in Philadelphia the oldest American scientific society, and here he performed the first significant experiments in physics of the New World. He would have eagerly supported the Institute in its aims and activities, and he is fittingly commemorated in its name.

To be included in this celebration of scientific advance in the home of Franklin, my own native city, is a privilege; and I beg to express my hearty appreciation of the very great honor which the Institute has conferred upon me.

As the title on the program indicates, my pleasant duty now is to speak to you on the fundamental properties of the elements, which have formed the chief subject of my chemical and physical studies. At the outset one may well ask: What are the elements, and what shall we designate as their fundamental properties? In these iconoclastic days several of our old scientific idols seem to have been shattered. If uranium and radium are only transitory, may not the other so-called "elements" also be slowly decomposing? In this case, ought we to count them as elements at all? Moreover, if, as some suppose, the atom is made up of nothing but electrons (positive and negative), what has become of the old atomic theory?

These questions, disturbing although they may seem

to be, are easily answered. Perhaps, from a philosophical and etymological point of view, the chemical atom no longer deserves its name; but the fact remains that in all the ordinary affairs of life our relations with the chemical elements primarily concerning us are unchanged by all the fascinating new knowledge. These same old elements remain as permanent as they ever were; and the only satisfactory explanation of the definite proportions by weight in which they combine is now, as of yore, the assumption of ultimate, undestroyed (if not indestructible) particles or chemical "atoms." The atomic theory is indeed even more convincing today with regard to mundane chemical affairs than it was before the dawn of radio-activity.

Of course, no one pretends nowadays that the chemical elements are to be considered as absolutely incapable of decomposition. Even supposing, however, that in the hottest stars some of them disintegrate, on earth, at least, they are amazingly permanent. It is concerning the earthly chemical elements, therefore—the old-fashioned kind of half a century ago—that I have to speak.

These elementary chemical substances build up everything about us, as well as our own bodies. It has always seemed to me, therefore, that the fundamental attributes which determine their behavior are worthy of very careful scrutiny.

Among the most fundamental of attributes, if not the most significant of all, is the tendency possessed by the elements to combine in definite proportions by weight. This we explain, as already stated, by the assumption that all matter is made up of atoms. One cannot believe that these atoms should have anything so important as their weight decided by mere chance or accident. Therefore, I chose the study of the atomic weights as the first of the fundamental properties to be investigated, and perhaps half of my time during the last thirty years has been devoted to this subject.

Great accuracy in the work was sought for several reasons, the most important of which was an earnest desire to find if possible the suspected mathematical relationship between these fundamental quantities. Such a relationship, if discovered, would greatly deepen our insight; and if it is to be found the data to be compared must be determined as accurately as possible.

Another reason for taking great pains in determining atomic weights is the fact that these figures are used by chemists throughout the world in their daily work oftener than any other series of data. All the manifold happenings of Nature occur in material built up of these same atoms. If we are to analyze or synthesize, or in any way have to do with the quantitative relations of reacting chemical substances under any circumstances, we must ultimately turn to the atomic weights for help. It is not too much to say that the atomic weights are the basis of quantitative chemistry.

More than two thousand years ago Plato said: "If from any art that which concerns weighing, measuring and arithmetic is taken away, little remains of that art." To-day we may paraphrase this saying as follows: "If from chemistry are taken away the atomic weights (or other numerical data representing the same definite proportions), little will remain of that science." As a science becomes more scientific it becomes more quantitative, and greater accuracy in the determination of its fundamental mathematical basis is required.

There is not time this afternoon to go into the details of many determinations of nearly thirty atomic weights carried out during as many years at Harvard. The effort was made to build upon the basis provided by the careful work of Berzelius, Marignac and Stas, with the help of the new discoveries in physical chemistry concerning solubility, hydrolysis, adsorption, and solid solu-

tion. Metals were compared, as to their combining proportions, especially with chlorine, bromine and iodine; moreover, many other careful comparisons likewise were made, as, for example: oxygen with silver through lithium chloride and lithium perchlorate; silver into nitrogen and sulphur through silver nitrate and sulphate; oxygen with carbon and sulphur sodium carbonate and sulphate, and many others. These, taken together, tend to put our whole table of atomic weights upon a stabler basis. The elements of which the atomic weights have been determined under my own immediate supervision are the following: copper, barium, strontium, calcium, magnesium, zinc, nickel, cobalt, iron, uranium, cesium, sodium, potassium, chlorine, nitrogen, silver, sulphur, carbon, lithium and radio-lead. To these should be added, as part of the Harvard contribution, those studied by my most energetic pupil in this line of work, Prof. G. P. Baxter, long since an independent investigator on his own account: arsenic, bromine, cadmium, chromium, iodine, lead meteoric iron and nickel, manganese, neodymium, praseodymium, and phosphorus. The most interesting outcome of my work is perhaps the discovery that lead from radio-active minerals possesses an atomic weight distinctly less than that of ordinary lead—206.1 instead of 207.2—although it gives the same spectrum.

If I were to sum up in a few words the lessons of these protracted investigations, I should be inclined to say that the secret of success in the study of atomic weights lies in carefully choosing the particular substances and processes employed, and in checking every operation by parallel experiments so that every unknown chemical and physical error will gradually be ferreted out of its hiding-place. The most important causes of inaccuracy are: the solubility of precipitates and of the material of containing vessels; the occlusion of foreign substance by solids, and especially the presence of retained moisture in almost everything. Each of these disturbing circumstances varies with each individual case. Far more depends upon the intelligent choice of the conditions of experiment than upon the mechanical execution of the operations, although that, too, is important. I have often quoted the innocent remark which has occasionally been made to me: "What wonderfully fine scales you must have to weigh atoms!" and have endeavored to point out that the purely chemical work, which precedes the introduction of the substance into the balance-case, is much more important than the mere operation of weighing.

Laboratory work alone can furnish us with accurate values of the atomic weights. No speculative method involving higher mathematics has as yet been able to solve definitively the cosmic puzzle of their relative magnitudes. In this direction, as in many others, chemistry is still largely an inductive science. When we have discovered the realities, we shall be in a position to attempt to explain them. In the meantime more accurate views, discovered little by little through patient investigation will be of use to the thousands of men throughout the world who daily employ these fundamental data of chemistry.

Matter possesses not only the fundamental properties of weight and mass, measured (from the chemical point of view) by the combining proportions of the elements, but also an equally fundamental attribute which causes it to occupy space. Thus, side by side with the study of weight and mass, the study of volume deserves close attention. This latter property is more changeable and more puzzling in its varied manifestations than the constant attributes of weight and mass. Almost every solid expands, occupying more space as it is heated, expands yet more in the act of melting, and finally

swells up into an altogether disproportionate volume when it is converted into vapor. In each of these states of matter the application of pressure produces a lessening of the volume—very small, but still perceptible in the case of solids, usually greater in the case of liquids, and still very much greater in the case of gases. The behavior of gases is very similar in each case: here the molecules must be far apart. On the other hand, solids and liquids behave in a manner entirely different from gases and entirely different from one another. The molecules must be very near one another, and the specific nature of each must come greatly into play. Even for any single substance the space-filling relations of the solid and liquid form are highly complex, and when comparison is made between different substances the complexity is vastly increased; yet none of these varying manifestations of the property of occupying space can be accidental. Each must have its inner significance, and the relation of each to the other cannot but be fundamentally connected with the ultimate nature of the substance concerned. Some of the relations are opened to us by the science of thermodynamics; but many of the data must be found, like the atomic weights, by experiment alone.

These considerations led me, nearly twenty years ago, to begin the study not only of the space occupied by the elements, especially in their liquid and solid states of aggregation, but also of many other related fundamental properties of the elements and their compounds, including the effect of increasing temperature and increasing pressure. Some of the data needed in this study had already been provided by the preceding work of others, but particularly in the case of compressibility, of which I wish especially to speak, very few data had been gathered even as recently as fifteen years ago. Only three or four elements had been carefully studied, and these by methods of doubtful efficacy. Hence the first step was to devise a simple and accurate method capable of determining the exceedingly small compressibilities of the solid elements. This method was devised in 1903, and with its help the compressibilities of nearly forty elements have been determined with sufficient accuracy to trace with some precision their relations to one another and to the bulk occupied by these same elements. Bridgman has since carried the determination of a few of these to much higher pressures.

The outcome is highly interesting. If the elements are arranged in the order of their atomic weight, we find that the compressibilities show a very well-marked alternating periodic increase and decrease as the atomic weight progresses. This fluctuation parallels in remarkable fashion the periodicity of the atomic volumes noticed long ago by Lothar Meyer. It appears that when an element has a large atomic volume (that is to say, when the bulk occupied by its atomic weight in grammes is large) the compressibility also is large, and *vice versa*; and the changes are of the same order in the two cases. That these two properties are fundamentally connected no one can doubt after studying the parallel curves showing their similar progression with increasing atomic weight. Neither can one doubt that in the tracing of this parallelism a real step has been made in the study of the nature of the element.

Other properties, more or less related, also have been shown to have analogous rhythms.

One may well ask: Can any conceivable interpretation be found for such parallel rhythms, analogous to Dalton's interpretation of the combining weights of the elements? In other words, can we refer effects concerned with the space occupied by gross matter to the atoms themselves, somewhat as the combining proportions of the elements are referred to the weights of the atoms? It seems to me that this can be done.

If one assumes that the practical bulk of the atoms in solids and liquids is compressible, most of these results fit naturally into their expected places. Those atoms which are much distended (that is to say, have large atomic volume) would be expected to be the most compressible. We should expect also to find that increasing chemical affinity, by pulling the atoms more and more together, would likewise cause compression and, therefore, diminish volume; and cohesive affinity would have the same effect. There is much evidence to show that this interpretation is a reasonable one, but time forbids again that the details should be entered into here. The hypothesis is pragmatic; it considers, not the hypothetical space which may or may not be occupied by an imaginary center or core in the atom, but rather the space which the atom actually requires in solids and liquids. That this space is definite and significant is proved beyond cavil by such curves as those to which I have referred, as well as many other facts concerning solids and liquids. One may well hope that the combined following of this trail may lead one to heights from which a broader view of the materials constructing the universe may be obtained. But even if the hypothesis should some time be found wanting, it has served already a purpose helpful to progress, for it has stimulated many researches leading to the acquisition of new facts. These will stand in the future, whatever may be the fate of the theory.

Do these investigations concerning ultimate properties of things and these hypotheses concerning the correlation of the properties seem to be remote from the pressing problems of humanity? Not so. We must remember that applied science follows in the footsteps of theoretical science. The laws of chemistry cannot be adequately applied until they have been discovered. Only by researches delving into the hidden secrets of Nature by some such processes as these can new discoveries in the realm of pure science be made; and no one can tell how great may be the gain to the philosophy of Nature, as well as to the daily lives of men.

The vital importance of chemistry to modern civilization is well known to this distinguished audience. Someone has wisely remarked that, whereas the nineteenth century was primarily devoted to advance in mechanical and electrical directions, the twentieth century bids fair to be an essentially chemical century. In war—now, alas! devastating the earth—as well as in the lasting peace for which we hope, chemistry is bound to play an all-important part. We perceive that every manufacture is concerned with chemical substances; we realize that recent chemical discoveries have revolutionized the preparation of many things essential to our life and have initiated entirely new industries of great importance and benefit to mankind. The great war has only intensified our appreciation of these facts. We recognize also that even we ourselves, so far as our material existence is concerned, are chemical machines, and that our every thought and act is intimately bound up with chemical reactions, without which neither thought nor act could come into being. Let us hope that the triumphs of chemistry in the future will be used not only for furthering manufacture and agriculture, thereby rendering life more comfortable and prosperous; but, also, above all, for advancing hygiene and medicine to a point where the physician will be able really to understand the complex anomalies which confront him every day. Let us hope, too, that with this practical progress may be united the growth of a broader and saner philosophy of Nature, founded upon a truer knowledge of the materials composing the universe and of the energy which animates it. To such ends, full of blessing to humanity, let us dedicate the science in the future.

The Dyestuff Tariff Before Congress

When in our issue of April 15, 1916 (page 407), we commented on the defeat in the Senate of the Lodge dyestuff tariff amendment to the sugar bill, we remarked that it seemed unbelievable that this should be the end of the dyestuff tariff fight in the present Congress, and that we preferred to take it as part of the political game. This view has proven true. The dyestuff tariff fight has been renewed, and the game is on again, through the action of the Ways and Means Committee.

The new general revenue bill of the Administration, now before Congress, contains besides provisions for an increased income tax and for a tax on gross receipts from the sale of munitions of war, also a provision for the creation of a tariff commission, as proposed in the recent bill offered by Mr. Rainey of Illinois, further an anti-dumping clause, and a new dyestuff tariff.

The anti-dumping clause reads as follows:

"That it shall be unlawful for any person importing or assisting in importing any article from any foreign country into the United States to commonly and systematically sell or cause to be sold such articles within the United States at a price substantially less than the actual market value or wholesale price of such articles, at the time of exportation to the United States, in the principal markets of the country of their production, or of other foreign countries to which they are commonly exported, after adding to such market value or wholesale price freight, duty and other charges and expenses necessarily incident to the importation and sale thereof in the United States.

"Provided, that such act or acts be done with the intent of destroying or injuring an industry in the United States or preventing the establishment of an industry in the United States, or of restraining or monopolizing any part of the trade or commerce in such articles in the United States.

"Persons convicted of violating this provision are punishable by a \$5,000 fine or one year's imprisonment or both. Any person injured by violations may sue the defendant and recover threefold damages sustained and costs."

The proposed new dyestuff tariff is as follows:

"Sec. 400. That on and after the day following the passage of this act, except as otherwise specially provided for in this title, there shall be levied, collected and paid upon the articles named in this section when imported from foreign countries into the United States, or into any of its possessions, except the Philippine Islands and the islands of Guam and Tutuila, the rates of duties which are prescribed in this title, namely:

"Free List—Group I. Acenaphthene, anthracene, benzol, carbazol, cresol, cumol, fluorene, methylantracene, methylnaphthalene, naphthalene, pyridin, quinolin, toluol, xylol, crude coal tar, pitch of coal tar, dead or creosote oil, anthracene oil, all other distillates which on being subject to distillation yield less than 5 per centum of tar acids in the portion of distilling below 200 deg. C., and all other products that are found naturally in coal tar, whether produced or obtained from coal tar or other source, and not otherwise specially provided for in this title, shall be exempt from duty.

"Dutiable List—Group II. Amidonaphthol, amidophenol, amidosalicylic acid, aniline oil, aniline salt, anthraquinone, binitrobenzol, binitrotoluol, binitronaphthalene, binitrochlorobenzol, benzaldehyde, benzylchloride, benzidin, chlorophthalic acid, cumidin, dianisidin, dimethylanilin, dioxynaphthalene, diphenylamin, methylanthraquinone, metanilic acid, nitrobenzol, nitrotoluol, nitronaphthalene, nitraniline, nitrophenylenediamine, nitrotrouenediamine, naphthylamine, naphthol, naphthylenediamine, phenol, phthalic acid, phthalic anhydride,

phenylenediamine, phenylnaphthylamine, resorcin, salicylic acid, sulfanilic acid, toluidin, tolidin, tolylenediamine, xylidin, or any sulfoacid or sulfoacid salt of any of the foregoing, all other distillates which on being subjected to distillation yield 5 per centum or more of k.r. acids in the portion distilling below 200 deg. C., and all other products obtained, derived or manufactured in whole or in part from the products provided for in Group I, all the foregoing not colors, dyes or stains, photographic chemicals or explosives, and not otherwise provided for in this title, 15 per centum ad valorem.

Group III. All colors, dyes or stains, whether soluble or not in water, color acids, color bases, color lakes, photographic chemicals or explosives, not otherwise specifically provided for in this title, when obtained, derived or manufactured in whole or in part from any of the products provided for in Groups I and II, including natural alizarin and indigo, 30 per centum ad valorem.

"Sec. 401. That on and after the day following the passage of this act, in addition to the duties provided in Sec. 400, there shall be levied, collected and paid upon all articles contained in Group II a special duty of 2½ cents per pound, and upon all articles contained in Group III (except natural and synthetic alizarin and dyes obtained from alizarin, anthracene and carbazol; and natural and synthetic indigo and all indigoids, whether or not obtained from indigo), a special duty of 5 cents per pound.

"During the period of five years, beginning five years after the passage of this act, such special duties shall be annually reduced by 20 per centum of the rate imposed by this section, so that at the end of such period such special duties shall no longer be assessed, levied or collected; but if at the expiration of five years from the date of the passage of this act the President finds that there is not being manufactured or produced within the United States as much as 60 per centum in value of the domestic consumption of the articles mentioned in Groups II and III of Sec. 400, he shall by proclamation so declare, whereupon the special duties imposed by this section on such articles shall no longer be assessed, levied or collected.

"Sec. 402. That paragraphs 20, 21, 22 and 23 of Schedule A of Sec. 1 of an act entitled 'An act to reduce tariff duties and to provide revenue for the government, and for other purposes,' approved Oct. 3, 1913, and paragraphs 394, 452 and 514, and the words 'carbolic' and 'phthalic' in paragraph 387 of the 'free list' of Sec. 1 of said act, and so much of said act or any existing law or parts of the law as may be consistent with this title are hereby repealed."

To understand clearly the scope of the proposed new dyestuff tariff of the *Kitchin bill* just quoted, it must be compared with the *Underwood tariff*, now in force since 1913, and with the proposed *Hill bill*, based on the recommendations of the chemical and dyestuff committee of the New York Section of the American Chemical Society, of which full details were given in our issues of December, 1914, Vol. XII, page 753, and Feb. 1, 1916, Vol. XIV, page 125.

From present developments it is evident that without exception everybody agrees that the rates of the Underwood tariff are absolutely insufficient. It provides a duty of 30 per cent ad valorem on aniline dyes and 10 per cent on intermediates, alizarin and anthracene dyes and indigo are free. There is no surtax per pound on anything.

The Hill bill represents what would be needed for such purpose according to the unanimous convictions not only of the present American dye makers, but of the American chemical industry in general.

The Kitchin bill introduces a new and very interesting feature into tariff matters by proposing a time limit (second paragraph of Sec. 401 quoted above). But it differs from the Hill bill also in two other points.

Firstly, with respect to the intensity of protection (value of duty), the Hill bill places a duty of 15 per cent ad valorem on intermediates and 30 per cent on finished dyes; the Kitchin bill does the same. But in addition to this, the Kitchin bill adds a "special duty" of 2½ cents per pound on the intermediate and 5 cents per pound on finished dyes, while the Hill bill provides for 3¾ cents per pound on the intermediates and 7½ cents per pound on finished dyes. Thus the amount of the special duty considered necessary by the chemical industry according to the Hill bill is reduced in the Kitchin bill by 33 1/3 per cent.

Secondly, with respect to the width or extension of the protection, the Hill bill tries to protect the new dyestuff industry all around. The Kitchin bill does not, as it exempts alizarine, anthracene and indigo from the additional "special duty" (Sec. 401, first paragraph).

Other matters have naturally come up, such an appeal to place an equal duty on coal-tar medicinals as on dyestuffs. Without entering into a discussion of the fairness of such a proposal, we do not think it likely that the present Congress will do much more than decide between the Kitchin bill and the Hill as they stand. On what we believe are the principal points to be considered in reaching this decision we comment on our first editorial page.

Metallurgy in Ontario

The annual report of Arthur A. Cole, engineer for the Ontario Government Railway, on the mining industry in northern Ontario during 1915, has just been issued. As usual, it contains an unusual amount of interesting information and data on mining and metallurgy in the remarkable Cobalt and Porcupine districts. Ontario is now the largest gold and silver-producing Province in Canada, yielding 44 per cent of the gold and 87 per cent of the silver. The increased cost of supplies during 1915 was partly compensated by the increased price of metals, but the greatest compensation came in the way of improvement in the work whereby costs per ton were materially reduced. The following comparative statement of the cost of milling supplies used at Cobalt will give an idea of the increase that has taken place:

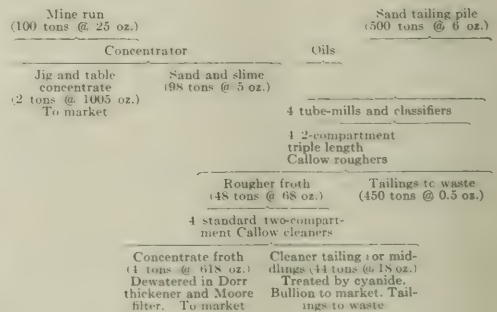
Material	Ante-Bellum	March, 1916
Alumina dust, lb.	\$0.34-\$0.38	\$0.75-\$0.90
Caustic soda, 100 lb.	1.30	7.50
Chromosulphic acid, 100 lb.	4.16	7.58
Cyanide-sulphate, lb.	0.15	0.16
Cyanide-sulphate, lb.	0.15	0.20
Mercury, 75 lb.	37.00	200.00-300.00
Pebbles, Fresh, ton f.o.b. New York	9.75	13.25
Pebbles, Danish, ton f.o.b. New York	13.00	15.00-16.00
Sulphuric acid, 100 lb.	1.27	3.90
Sulphuric acid, 100 lb.	1.30	1.95
Zinc dust, lb.	0.065	0.38-0.35

At Porcupine, which is about 100 miles northwest of Cobalt, still higher prices have prevailed and advances of from 8 per cent to 427 per cent in the cost of mill supplies is recorded.

Porcupine continues to be the principal gold-producing camp, and the output for 1915 was valued at \$7,580,766, as against \$5,203,229 for 1914. Cobalt is the main source of silver, having produced 234,000,000 ounces since its discovery in 1904. The output for 1915 was 23,653,713 ounces, a decrease from the previous year when the output was 25,162,841 ounces. The production of silver from Cobalt has constantly decreased since

1911, when the high point of 31,507,791 ounces was reached. There were nine companies at Cobalt, each of which produced more than one million ounces of silver during 1915. Dividends and bonuses paid by Cobalt companies in 1915 amounted to \$4,523,415; the grand total since the discovery of the camp is \$57,614,202.

A number of Cobalt companies are now employing the flotation process. The largest plant is that of the Buffalo company, which experimented first with a 50-ton plant of the Callow pneumatic type. A permanent plant of 600 tons capacity is now being erected for the treatment of 500 tons per day of accumulated tailings from water concentration and of 100 tons of mine rock. The fine-grinding equipment will consist of four 5 ft. 6 in. by 20 ft. tube-mills, and the flotation plant of four two-compartment, triple-length Callow cells to be used as roughers and four standard two-compartment cells as cleaners. The old cyanide plant will be used for de-watering flotation concentrate and for the cyanidation of flotation middling. A flow-sheet of the flotation plant is herewith given.



The Vulcan Soot Cleaner Company has recently issued a catalog describing its product, the Vulcan soot cleaner. The catalog is nicely illustrated and the frontispiece is a four-color reproduction of actual specimens of soot from different boilers and with different fuels. The different sections of the catalog contain complete information as to what soot really is, and how it can be economically removed.

Potash in British Columbia.—The Canadian Potash and Algin Co. (Ltd.) was organized in 1915 and a plant established at Sydney, British Columbia. It is now utilizing from 30 to 40 tons of raw kelp daily in the manufacture of fertilizer, according to Commerce Reports. The product is a fine, dry, but heavy powder. Plans are being made to enlarge the plant and install special machinery for the extraction of other materials from kelp.

It is believed by the promoters of the industry in this Province that the manufacture of iodine and potash, without the production of by-products, would not prove very profitable in normal times, but the increase in the price, especially of potash, on account of the war, will enable the British Columbia company to include these and other by-products in the output of the factory at Sydney.

Algin, which will be made one of the specialties of the local plant, is said to possess a viscosity many times greater than that of starch or gum arabic. The chief use of algin is for the sizing of fabrics, the effect being to give the material treated the appearance of waterproof sheeting, but leaving it more elastic than when treated by other customary waterproofing materials.

Catalysis in the Formation of Gasoline from Kerosene

BY GUSTAV EGLOFF AND ROBERT J. MOORE

In the formation of gasoline from heavier petroleum oils three distinct methods may be recognized:

1. THE TWO-PHASE SYSTEM, GAS AND LIQUID.
 - a. Distillation in an ordinary still at atmospheric pressure.
 - b. Distillation under greater than atmospheric pressure.
2. THE ONE-PHASE SYSTEM, GAS.
 - a. The cracking takes place at atmospheric pressure.
 - b. The cracking takes place at greater than atmospheric pressure.
3. THE THREE-PHASE SYSTEM, GAS, LIQUID AND SOLID.

The dissociation of the heavier hydrocarbons into lighter hydrocarbons takes place by the use of catalytic and chemical agents.

Of the three methods the two-phase system is the oldest. In this system there is always present liquid oil in the still in equilibrium with the oil gas above the liquid layer. Silliman¹ in 1855 predicted that in ordinary distillation of heavy oils decomposition takes place, giving lighter oils. Since that time various processes have been devised for the production of the more valuable oils as the particular uses of the times called for. Before the advent of motor cars the production of kerosene was important, at present gasoline has become the primary product. The most important process now for the increased production of gasoline is the Burton.² This is a gas-liquid system under a pressure of approximately seventy pounds. Other important processes of the first mentioned type are those of Brooks, Bacon & Clark,³ and Snelling.⁴

THE GAS-PHASE METHOD

The gas-phase method has come rapidly to the fore in the past few years. This system is fundamentally different from the foregoing one in that no liquid is present and only the vaporized oil is cracked. Not much has been done with this system, however, at atmospheric pressure due to the highly unsaturated aliphatic formation and low yields of gasoline.⁵

The gas-phase method under pressures greater than atmospheric has been thoroughly worked out by Rittman.⁶ He has thermolized paraffin, paraffin-asphaltic and asphaltic base petroleum, kerosene, gas oils and fuel oils in the gaseous phase under pressure.

THE THREE-PHASE METHOD—GAS, LIQUID AND SOLID

In the use of catalysis for the conversion of heavy oils to light boiling fractions a number of metals and their chlorides have been tested. Those usually adopted for their catalytic effect have been aluminium, zinc and magnesium.

The method usually employs anhydrous aluminium chloride or passes hydrogen chloride or chlorine over metallic aluminium in a still. In this reaction the solid phase, aluminium or its chloride, is in equilibrium with the liquid oil and the gas above it. Friedel and Crafts⁷ published in 1878 the findings that aluminium chloride gave in contact with heavy oils, oils of a much lower

volatility. G. W. Gray¹ in 1913 took out two process patents upon this idea as also did McAfee² in 1915. McAfee specifies the use of metals for the formation of gasoline, paraffin and lubricating oils from heavy petroleum. He describes the action of anhydrous aluminium chloride upon three type oils: paraffin, paraffin asphaltic and asphaltic base oils. By the use of anhydrous aluminium chloride the results given in Table I were obtained by him:

TABLE I

Paraffin base oil	100 c.c.	100 c.c.	100 c.c.
Paraffin asphaltic base oil	100 c.c.	100 c.c.	100 c.c.
Asphaltic base oil	100 c.c.	100 c.c.	100 c.c.

OBJECT

The formation of gasoline from the thermal and pressure decomposition of heavy oils in the gas-liquid condition has been thoroughly studied. Rittman's work upon the gas phase system of thermal and pressure decomposition of various oils for the production of gasoline has been inclusive. Contrasted with the work that has been done on the gas-phase and the gas-liquid system, comparatively little material can be found on the gas-liquid-solid system. It was with the view of getting more definite information on this latter type system that the following experiments were undertaken. Thus the effect of the catalytic or chemical action of the chloride of metals and non-metals upon gasoline formation from a paraffin base kerosene has been studied.

Experimental Procedure

The experiments were carried on in an 800-c.c. Kjehldahl flask fitted with a two-holed cork stopper. Through one hole was attached a Ginsky distilling head connected to a 24-in. Liebig condenser. Through the other hole a glass tube extended to the bottom. Through this was passed the hydrogen chloride gas generated in a Freas apparatus by dropping concentrated sulphuric acid on ammonium chloride. The gas was washed and regulated by a Dreschel wash bottle containing concentrated sulphuric acid. The chlorine used was generated by dropping concentrated hydrochloric acid on potassium permanganate.

A charge of 400 or 500 c.c. kerosene and 10 per cent by weight of the catalyst was placed in the Kjehldahl flask, which was made airtight with sodium silicate and collodion, and heated in each case with a uniform size Bunsen flame. The average time of reaction was three hours.

The distillate in each case was measured and washed in a separatory funnel with sodium hydroxide solution. The oils from the phosphorus and selenium runs gave a bad odor due to the formation of phosphine and hydrogen selenide. After taking its specific gravity, 100 c.c. of oil was distilled in a standard Engler 100 c.c. flask, the cut to 150 deg. C. being taken as gasoline.

The characteristics of the reaction and the appearance of the distillates differed widely in the various runs. The color and clarity of the residue left in the Kjehldahl flask varied all the way from a slight reddish tinge and insignificant red precipitate, in the case of selenium, to a black muddy sludge, in the case of aluminium. This sludge, which appeared in several of the runs, was partly volatile and condensed in the Ginsky head and condenser, and even came over into the distillate offering a certain amount of annoyance in clogging the apparatus. In the chlorine runs on phosphorus and sulphur the combination to form chlorides was so strongly exothermic that flashes of light were con-

¹Report on rock oil or petroleum from Venango Co., Pa. New Haven, 1855.

²Burton; U. S. Patents 1,049,667; 1,105,961.

³Brooks, Bacon & Clark; U. S. Patent 1,131,309; *J. Ind. & Eng. Chem.*, Vol. 7, 1915.

⁴Snelling; *Bull. Am. Inst. Min. Eng.*, 100,695, 1915.

⁵Egloff and Twomey, *Jour. Phys. Chem.*, 20,121, 1916. *MET. AND CHEM. ENG.*, 14,247, 1916.

⁶Rittman; *J. Ind. Eng. Chem.*, 7945, 1915; *Bulletin* 114, Bureau of Mines.

⁷*Chem. Ind. Jahr.*, 1411, 1873. English patent 4769, 1877.

¹English Patents 17,588 and 17,589.
²*Ind. and Chem. Eng.*, 17,77, 1915. *MET. AND CHEM. ENG.*, 14, 1916.
³*Trans. National Pet. Ass.*, 120, 1915. U. S. Patents 1,047,400.

tinually emitted under the oil and the system continued at boiling, even when the burner was removed.

OIL USED

The oil used in these experiments was a water white kerosene derived from a paraffin base Pennsylvania crude petroleum. The oil analyzed as stated in Table 2.

TABLE II

Specific gravity.....	0.800 at 15.5 deg. C.
Nitration test.....	0.8 per cent combined
Sulphuric acid test.....	0.2 per cent combined

DISTILLATION TEST USING STANDARD 100-C.C. ENGLER FLASK

First Drop 153 Deg. C.

Temperature	Per Cent by Volume
Deg. C.	
160	2.0
170	9.5
180	22.0
190	35.5
200	46.0
210	56.0
220	65.5
230	73.0
240	80.0
250	86.0
Residue	13.2
Loss	0.8

Experiments

With hydrogen chloride five different elements were used, sodium, magnesium, aluminium, zinc and selenium. With chlorine were used sulphur, selenium, phosphorus, silicon, aluminium and magnesium. With the exception of sulphur, phosphorus and sodium, which soon melted under the heated oil, the elements were used in a finely powdered form.

EXPERIMENTAL DATA

TABLE III—PER CENT RECOVERED, SPECIFIC GRAVITY AND DISTILLATION ANALYSIS OF THE RECOVERED OIL. FOR HYDROGEN CHLORIDE

	Sodium	Magnesium	Aluminium	Zinc	Selenium
Per cent recovered..	70.0	75.1	71.0	70.0	45.0
Specific gravity.....	0.781	0.781	0.750	0.770	0.771
1st distill. drop.....	140 deg.	143 deg.	31 deg.	135 deg.	132 deg.
Per cent to 150 deg. C.....	7.5	1.5	52.5	7.0	4.0
Per cent to 160 deg. C.....	20.0	9.0	61.5	16.5	38.0
Per cent to 170 deg. C.....	37.5	35.5	75.0	38.0	70.0
Per cent to 180 deg. C.....	58.0	55.0	84.0	58.0	85.0
Per cent to 190 deg. C.....	71.5	70.0	88.5	73.0	92.0
Per cent to 200 deg. C.....	85.5	81.0	92.5	85.0	.....
Per cent to 210 deg. C.....	95.0	88.0	.....	92.0	.....
Per cent gasoline on basis of recovered oil	7.5	1.5	52.5	7.0	4.0

TABLE IV—PER CENT RECOVERED, SPECIFIC GRAVITY AND DISTILLATION ANALYSIS OF THE RECOVERED OIL. FOR CHLORINE

	Magnesium	Aluminium	Silicon	Phosphorus	Sulphur	Selenium
Per cent recovered..	62.5	77.8	60.0	55.0	67.5	48.0
Specific gravity.....	0.767	0.778	0.796	0.780	0.788	0.780
1st distill. drop.....	148 deg. C.	62 deg. C.	146 deg. C.	134 deg. C.	140 deg. C.	135 deg. C.
Per cent to 150 deg. C.....	0.5	21.5	1.0	3.0	1.0	11.0
Per cent to 160 deg. C.....	8.5	31.5	12.0	18.5	8.5	33.0
Per cent to 170 deg. C.....	27.0	35.0	34.0	39.0	32.0	39.5
Per cent to 180 deg. C.....	48.5	62.0	55.5	58.0	54.0	81.5
Per cent to 190 deg. C.....	62.0	78.0	54.0	73.5	75.0	92.0
Per cent to 200 deg. C.....	76.0	88.5	84.5	85.0	87.0	.....
Per cent to 210 deg. C.....	84.5	94.5	92.0	91.0	95.0	.....
Per cent gasoline on basis of recovered oil	0.5	21.5	1.0	3.0	1.0	11.0

Discussion of the Data

Table 3 tabulates the analytical results of passing hydrogen chloride over the metals sodium, magnesium, aluminium, zinc and the non-metal selenium in the conversion of kerosene to gasoline. The per cent of oil

recovered, the specific gravity and distillation figures of the recovered oil are given. It is to be noted that aluminium chloride gives a specific gravity of 0.750 and the first drop from the end of the condenser at 31 deg. C., which gives an idea of the high volatility of the converted oil. The other metals and non-metal give gravities of the recovered oil ranging from 0.770 to 0.781 and the first drop from 182 deg. C. to 143 deg. C. The yield from aluminium and hydrogen chloride treatment of kerosene in the recovered oil is 52.5 per cent gasoline, whereas, the others range from 1.5 to 7.5 per cent. No satisfactory explanation is at hand why aluminium chloride should give such greatly increased yield of gasoline when compared to the chlorides of the other elements.

TABLE V—THE PER CENT OF GASOLINE UPON THE BASIS OF OIL USED FROM THE PASSING OF HYDROGEN CHLORIDE OVER METALS AND NON-METALS

	Magnesium	Selenium	Zinc	Sodium	Aluminium
Per cent gasoline.....	1.1	1.8	4.9	5.3	37.3

TABLE VI—THE PER CENT OF GASOLINE UPON THE BASIS OF OIL USED FROM THE PASSING OF CHLORINE OVER METALS AND NON-METALS

	Magnesium	Silicon	Sulphur	Phosphorus	Selenium	Aluminium
Per cent gasoline.....	0.3	0.6	0.7	1.7	5.3	15.9

Table 4 tabulates similarly to Table 3 the results of passing chlorine over the metals magnesium, aluminium, and the non-metals silicon, phosphorus, sulphur and selenium.

The specific gravity of the recovered oil from aluminium chloride treatment gave 0.778, with 62 deg. C. for the first drop. The chlorides of the other elements gave a specific gravity range of 0.780 to 0.796 and first drop between 134 deg. C. to 148 deg. C. The per cent of gasoline formation in the recovered oil for aluminium chloride was 21.5, and for the other chlorides between 0.5 to 11.0 per cent. Again the chloride of aluminium gave a much higher yield than the other chlorides.

A comparison of Tables 3 and 4 indicates clearly the higher yields of gasoline from the aluminium chloride formed by passing hydrogen chloride over the metal in comparison with its formation from chlorine. Excess of chlorine in the sphere of the reaction seems to inhibit somewhat the velocity of the reaction in gasoline formation from kerosene, whereas the hydrogen chloride excess increases the reaction velocity. Furthermore excess of hydrogen chloride reduces the unsaturated compound formation to a negligible amount in the gasoline fraction.

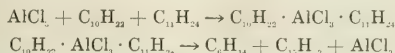
Tables 5 and 6 give the per cent of gasoline formation upon basis of the original kerosene used. Aluminium chloride formed from hydrogen chloride and aluminium gave 37.3 per cent, whereas using chlorine in its formation 15.9 per cent gasoline resulted. The per cent of gasoline from the chlorides of the other metals ranged between 0.3 to 5.3 per cent.

The Mechanism of the Reaction

As to whether the action of the chlorides of the metals or non-metals is simply that of an activator in the formation of low-boiling from high-boiling hydrocarbons, or whether addition compounds are formed which subsequently decompose into lower and higher volatility hydrocarbons is not definitely known as yet. The most likely mechanism of formation is by way of addition compounds of the chlorides with the hydro-

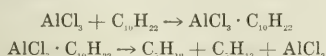
carbons of the starting oil. These addition compounds, not being stable at the temperature of the reaction, decompose into two or more compounds of the aliphatic group.

Perhaps the following hypothetical reactions will tend to make the addition and splitting off of the hydrocarbons clearer. In the kerosene oil, the paraffin hydrocarbons present are those with boiling points around Decane,¹⁰ Undecane, Tridecane, and higher molecular weight compounds. Let us take decane and undecane for our illustrative reaction of addition and decomposition:



In this assumed reaction the formation of hexane and pentadecane result with boiling points of 71 deg. C. and 270.5 deg. C. starting with decane B. P. 173 deg. C. and undecane 194.5 deg. C. Now in the reaction using the chloride of aluminium as catalyst, paraffins with boiling points around 71 deg. C. result when starting with an oil containing the compounds decane and undecane.

This illustration can be carried on so as to account for other hydrocarbons which are recovered in the gasoline. No unsaturated compounds were found in the gasoline fraction from the catalytic effect of passing hydrogen chloride over metallic aluminium. Unsaturation¹¹ was determined by absorption of the unsaturated compounds in sulphuric acid. The acid layer was water-white after shaking and allowing the two liquid layers to stand. But when chlorine was passed over the same metal, the gasoline fraction under similar treatment gave a deep reddish brown color in the acid layer, indicating clearly that unsaturated compounds resulted from this reaction. This brings us to the following hypothetical reaction of unsaturated compound formation:



The formation of amylene¹² and pentane would be indicated from this reaction. Gustavson's¹³ work is qualitative information in justification of the above assumed mechanism of reaction. He found that when a fraction of kerosene was treated with aluminium bromide and hydrogen bromide and then extracting the solution, the definite compound of aluminiumbromidebutylene $\text{AlBr}_3 \cdot \text{C}_4\text{H}_8$ was isolated.

SUMMARY

1. Three distinct methods for the conversion of heavy hydrocarbon oils into gasoline have been discussed. The single-phase gas system, the two-phase system of gas and liquid, and the three-phase system of gas, liquid and solid. The latter system has been treated in this paper.

2. Several hypothetical reactions have been shown to indicate the possible mechanism of reaction in the formation of low-boiling hydrocarbons from the action of aluminium chloride upon high-boiling point hydrocarbons.

3. The percentage of gasoline from kerosene due to the catalytic action of passing hydrogen chloride over the metals magnesium, zinc, sodium and aluminium gave the following results: magnesium 1.0 per cent, zinc 4.9 per cent, sodium 5.3 per cent, and 37.3 per cent for aluminium, all on the basis of the oil used.

4. The percentage yield of gasoline from kerosene due to the catalytic action of passing chlorine over the metals magnesium gave 0.3 per cent, aluminium 15.9

per cent, and for the non-metals silicon 0.6 per cent, sulphur 0.7 per cent, phosphorus 1.7 per cent, and selenium 5.3 per cent on the basis of the oil used.

5. The difference in the per cent of conversion to gasoline between the use of hydrogen chloride and chlorine upon magnesium and aluminium is marked. Hydrogen chloride upon aluminium gave 37.3 per cent yield, whereas chlorine, acting upon same metal, gave 15.9 per cent.

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Blast Furnace Irregularities and Their Treatment

BY J. E. JOHNSON, JR.

Regularity the First Requirement of Successful Operation

The keynote of successful operation of the blast furnace is regularity. I have tried in preceding chapters to make a picture of the delicate equilibrium which must be maintained between enormous forces, and I have tried to show that variations of only 1 or 2 per cent were enough to affect seriously the results of the operation, while a change of 5 or 6 per cent might be fatal.

The regularity required is of many kinds. First: uniformity of the stock charged; second: uniformity of its distribution into the furnace; third: uniformity of the blast in temperature and humidity; fourth: uniformity in the distribution of the blast in the furnace; fifth: uniformity in the quantity of blast blown per unit of time; sixth: uniformity in the kind of material to be produced. It may take days or even weeks to establish the absolute equilibrium which gives best results in cost, quality of product and output, and this cannot be secured at all except by regularity in all these factors. A temporary variation in only one of them may bring about conditions which will necessitate days of careful watching and adjusting in order to restore the furnace to the desired condition.

Undoubtedly the most important kind of regularity is that which leads to regular and uniform driving of the furnace, that is, to steady and continuous working. Many furnacemen have in times gone by followed the practice of tuning everything up for weeks and then making a sudden spurt in which gigantic outputs were secured generally, assisted by melting up a scrap accumulation of weeks, trusting that this spectacular performance would divert attention from the mediocre work which preceded, and the rotten conditions which followed the conclusion of such a spurt. But it is now well recognized not only by furnacemen but by managers that it is the long steady pull which counts rather than the spurt, and spurring for a record has very seriously declined in favor of the great benefit of the business.

The Furnace Plant Cannot Run Except When All Its Parts Run

The furnace plant is different from all other large plants in one particular. It has no reserves, no storage capacity, so to speak, at any point on the line so as to permit one part to run and store up a supply of its particular function that lasts while the function itself is suspended for repairs or the like. For instance, in the steel plant, not counting the mixer, since that may be classed with the bins of the furnace system, there is a storage interval of at least a few minutes before tapping, then after tapping the steel is poured into ingots and these are many hours in making the round trip,

¹⁰Landolt & Jahn, Z. Phys. Chem., 10, 363, 1892.

¹¹Eglioff and Twomey, MET. AND CHEM. ENG., 14, 247, 1916.

¹²Work now going on in this laboratory for the isolation of unsaturated and saturated compounds from the cracking of petroleum, shows that amylene and pentane are readily formed from high molecular weight paraffin hydrocarbons.

¹³Chem. Zentr., 53, 12, 353, 1881.

though the actual time of pouring and stripping is but a small fraction of this. This means that there is a considerable volume in the ingot molds. Then there is storage again after the ingots are removed from the molds and put into the soaking pit, and so on, there being some storage capacity, be it great or small, in almost every part of the process, but in the blast furnace this condition does not exist. It is necessary that *all* the parts of the furnace operation be co-ordinated with one another in the closest possible way.

If the blowing engine stops the furnace stops instantly, and more than that, if the blowing engine stops without the furnace being flushed or cast the cinder is likely to fill the tuyeres which causes an enormous amount of labor for its removal and a delay of many hours. If the filling apparatus becomes deranged and the furnace can no longer be filled, it may be run for a short time, but if for more than an hour or two, even though filling be resumed at the end of that time, the stock filled immediately after the intermission is deprived of a considerable proportion of the time and exposure to the gas which it should receive, and reaches the hearth in a raw condition, deranging the work of the furnace. Consequently, if the filling arrangements become deranged to any considerable extent the furnace must be cast and the blast taken off. If the stop is to be a long one the tuyeres must be plugged up for reasons already pointed out. If, on the other hand, the arrangements for disposing of the iron or the slag, particularly the former, become deranged, almost the worst condition of all arises, especially if the derangement is so great that the iron already in the furnace cannot be tapped out.

If it can be foreseen therefore that the iron cannot be taken care of as made, the furnace may be cast and shut down as before, but in none of these conditions is there any considerable margin of time, and it is true of the blast furnace as it is of no other industrial apparatus within my knowledge, that all the parts must function simultaneously, and stoppage of one stops all.

The Nature of the Irregularities

The variety of mishaps which can cause shutdowns of various kinds is almost infinite. They may be divided into two broad classes. First: those in which the derangement is of the furnace itself; second: those in which it is that of some of its secondary functions. That is to say, the furnace may be running beautifully, but a breakdown of the filling system shuts it down, or as was the most frequent cause of all within a few years, a breakdown of the blowing power stops it. These and all similar failures, external to the furnace itself, are more or less mechanical, and while plenty of them are serious enough and require enormous labor for their repair and cause great loss not only in the actual cost of the repairs themselves, but in the loss of time on the whole plant, they do not affect the furnace itself except as the result of a long stoppage, as has been described under that heading.

On account of the variety that is possible in such failures and the fact that the making of repairs in such cases does not differ from that of making similar mechanical repairs in other industries, I shall not attempt to describe them here.

Derangement of the Furnace Proper

With the other class of accidents or derangements those which affect the functioning of the furnace itself the conditions are very different. They are unlike anything else in industry, and the knowledge of how to handle them and restore the plant to operation would not be given by the most intimate acquaintance with all the other industries in the world. There are several degrees and varieties of these derangements, both

as to cause and as to effect produced. As to the causes the most frequent are, 1, heavy slipping; 2, internal explosions; 3, the breaking of a scaffold and the descent of the material which formed it into the hearth; 4, the cutting or bursting of a water-cooling member, such as a tuyere, cooler or cooling-plate; 5, breakouts; 6, a mistake in filling such as charging ore without sufficient fuel to take care of it.

The results of these various causes are, of course, very different when they are not serious, but strange as it may appear, when the results are serious they are practically always the same in a general way, though they vary infinitely in details. They are the chilling or partial chilling of the hearth of the furnace, so that the material can no longer be easily withdrawn in the molten condition; this causes the rest of the various conditions which follow. The reason for this is that a serious derangement from any of these causes brings about either the descent into the hearth of a large amount of insufficiently prepared material, or else a long stoppage of the furnace, which, occurring suddenly and without warning, means that no extra coke can be put into the hearth to meet it so that progressive freezing up occurs, its severity being proportional to the delay.

SLIPS

In the article on Mechanical Principles the actions which lead to sticking have been quoted from my paper, "Notes on the Physical Action of the Blast Furnace," and while the mechanism therein described may be subject to infinite variations of detail in that various circumstances affect and cause such sticking, the universal first remedy is the slacking of the blast so that reduced pressure below may cause the weight of the suspended material to bring it down. Slipping when almost continuous and not violent is spoken of as "sliding," and when even less violent, but still causing the excessive discharge of flue dust, as "dusting." I give below a further quotation from the same paper which covers both "kicking" or ordinary "slipping," and also those more violent accidents really deserving the name of explosions, which both in this country and others have, in some instances—fortunately only a few—resulted in bursting the furnace shell, or sometimes the bosh structure, with the violent ejection of the contents of the furnace.

EXPLOSIONS

"There come, however, occasionally, occurrences of this general type, but of so much greater violence and destructive effect than mere "slips" that they seem to require a further explanation.

This seems to be furnished by the fact that the conditions I have described may occur at any point in the furnace, and that the deeper they are the greater is the air-pressure, and also the weight of the ammunition in the air-gun thus formed; hence the greater the execution.

But if this occurrence take place so low in the furnace that the cavity formed reaches finally down to the tuyeres, a further condition arises, in which the cavity is filled not with gas but with air; and when the break in the obstruction comes, the incandescent carbon dust always present in the lower part of the furnace from the splitting up of the CO is precipitated (along with the other materials) into an atmosphere of compressed and heated air, giving precisely the conditions requisite to the production of an explosion of great violence, in which case the air-gun becomes a powder-gun, and is not infrequently burst by the charge. This accounts completely for the observed phenomena of these more violent occurrences.

As already explained, the "kicking" due to slips is

more violent and prolonged in proportion as the obstruction is deeper in the furnace. But there is still another reason for the shades of increasing violence, which make it almost impossible to tell where slips end and explosions begin; that is the varying quantity of unburnt air in the cavity above the tuyeres and the degree of its mixture with other gases. This is due to the gradual decrease in the depth of the layer of coke above the tuyeres. When this is no longer sufficient to burn all the oxygen to CO, CO₂ begins to appear, and when there is not enough to burn it all to this, free oxygen begins to appear, and its percentage thereafter steadily increases. It is evident that the precise point in this series of changes at which the slip takes place will influence profoundly the character of an explosion, and even the possibility of its occurrence."

One case is on record in Germany in which nothing but a stump of the furnace was left after the explosion. Another occurred soon after the introduction of Mesabi ores in the Shenango Valley, in which the furnace shell was completely wrecked. More recently at a furnace in the Pittsburgh district the bosh was torn wide open without a second's warning. The great steel bands around it, 10 in. by 1 1/4 in. and only about 1 ft. apart, were ripped in two as if they had been threads cut with a razor and almost the entire contents of the furnace were discharged through the great opening made, almost half the bosh wall being blown away.

These terrible accidents accompanied as they so often are by serious loss of life, each occur under different circumstances and with different results. Fortunately, they are too few in number to be classified broadly and accurately, but in general no two agree very closely. Many explanations have been given for each and every one, and a greater number of theoretical causes have been assigned for the production of the explosion which brings about such terrible results, but after careful consideration of them all I have been unable to find any cause as inherently probable, or with as few practical or theoretical objections as that advanced in the quotation just given.

Certainly if the fuel bed above the tuyeres burns down much below the top of the bosh while the balance of the stock stays suspended above it, we shall have a great cavity filled with an atmosphere containing free oxygen at a temperature well above 2500 deg. and under a pressure perhaps of 20 to 30 lb. If now we precipitate into this a great mass containing a large proportion of incandescent carbon in the condition of impalpable powder, what can we possibly have except a dust explosion under the conditions far more favorable to violence than those which have enabled such explosions to wreck coal mines, flour mills and other industrial operations almost without number?

Many other reactions have been proposed as the cause of these explosions, but not a single one that I have ever heard advanced will stand the test of representing the conditions truly and being at the same time chemically correct.

SCAFFOLDS

These can scarcely be treated separately from slips, since scaffolds are one of the most active causes promoting slips. Projecting out from the wall of the furnace they offer support to the charge column and in conjunction with the pressure of the blast from below they support its weight so completely that it ceases to descend until the blast is checked or some keystone of the crude arch formed dissolves away and the mass descends, causing a slip.

Scaffolds are of many and various kinds. It is probable that a large volume could be written concerning this subject alone had anyone the patience to collect all

the data available. In general, however, scaffolds confine themselves to the region from the top of the pasty zone downward. Some furnaces which work "tight" are said to have dust scaffolds, but I have always preferred to believe that this was a condition of tightness at a certain zone due to the continuous redeposition in that zone of carbon dissolved at a lower level, according to an action earlier described.

Leaving these we have only to deal with scaffolds formed of molten or semi-molten material. They may be a foot or two thick radially or they may form a complete floor across the furnace. Of the latter I have heard several times, but fortunately I have never seen myself. The blast furnace is understood so much better now that those occasions are becoming very rare if they have not gone forever. But scaffolds from a foot to several feet in thickness are still not uncommon; in plan they may extend from a bare lump on the side of the furnace to a complete ring all around it, almost as regular as if it had been built on purpose.

In regard to the latter I can speak with certainty for I have had the unusual experience of seeing such a scaffold in a "live" furnace, just after it had caused its victim to undergo one of the explosions which I have just described, and to throw out its entire contents to a point well below the scaffold. It was an experience that I shall never forget. I was at the time on the upper platform of a steeple-type blowing engine, which was running along quietly enough when suddenly something happened which I have never been able to compare to anything except the blow which an unsuspecting man might receive from a blackjack; he would be knocked to his knees for a moment and then get up and run away. The blowing engine seemed to receive just such a shock, and after a few seconds went on much more easily than before the shock had occurred.

A prolonged roar and a lively fusilade on the engine-house roof announced that something out of the common had happened. On going out to investigate I found that a real explosion had taken place and the furnace top was evidently completely deranged. The furnace was cast and stopped as soon as possible, and when we were able to reach the top we found the bell resting securely in the hopper on top of the lip ring instead of beneath it.

Investigation showed that it had been driven upwards with such force as to break the lip ring in two and force it up in the hopper until the bell could pass through it, then the lip ring dropped back to its seat with the bell on top of it. The enormous bell beam built up of heavy plates and angles was bent at a sharp angle, though the forces required to do this must have reached hundreds of tons. Other things were about in a similar condition.

After the top was cleaned off and cooled down enough to work two of us finally ventured to lean over far enough to look down inside; as several hours had passed all was then quiet and we could see a dull red "ring" scaffold running all around the furnace at a height that seemed up somewhere above the top of the bosh, and seemed to extend out some 3 ft. all around. As the furnace was 21 ft. in diameter this would have left a 15-ft. hole through the center. It may even be that the scaffold was greater and the hole smaller than this.

I take this case to be almost ideal proof of the accuracy of the theory of explosions described in the last section. The whole charge column taking advantage of some accidental variation, high pressure or the like, evidently came to rest on the top of the scaffold, and being at the top of the pasty zone it held there while the lower portion settled as the coke burned away. In a comparatively short time, two or three hours at the

most, the surface of the lower portion descended well below the top of the bosh and the height of the fuel bed was no longer sufficient to prevent the presence of some free oxygen in the space above it. Finally something happened to precipitate the suspended mass above through the central hole in the scaffold and the explosion, which I have so inadequately described, instantly followed.

It is easy to see that a ring scaffold of this kind is the most dangerous that we can have, in spite of its symmetry, because it furnishes such ideal support for the charge column and tends to stop the descent of the latter so completely. A scaffold on one side only tends to check the material on that side and to force the fines over to the far side of the furnace, the lumps running back under it. This produces a very uneven descent of the charge into the hearth and a highly improper distribution of the gas current through the descending charge, but this, though bad enough, is obviously not so serious as the complete suspension of the charge with results like those above described.

THE REMOVAL OF SCAFFOLDS

This is a subject concerning which we know far less than we should. Many furnaces which once become scaffolded never work satisfactorily again during that blast, while again others may get rid of the trouble completely and do as good work after as before. In general, there are three methods to be pursued. First: to restore conditions as nearly to normal as possible, running with a comparatively light burden and hoping to melt or wear the scaffold away whatever its position. Second: by careful watching of the working of the different tuyeres to try and locate the position of the scaffold and then try so to direct the filling as to overcome as far as possible its bad effects, or by directing the action of the furnace violently against it to wear it away. Third: by deliberately sacrificing the work of the furnace for a day or two, putting in a light burden with a considerable excess of whatever material will produce the most fusible slag, generally silica with a coke furnace, although silica and fluorspar would be better, lime and fluorspar for a charcoal furnace and by extra heat and dissolving action scour it bodily off.

In the case of a coke furnace I have known the ore burden to be almost entirely replaced by a great quantity of sand. Coke-furnace accretions always contain a considerable quantity of lime, as already pointed out, so when this great quantity of unfluxed silica reaches these accretions in the presence of a great excess of fuel to produce all the heat necessary, it at once tries to satisfy itself with bases by dissolving away the accretion. I have never tried this drastic remedy myself.

On the other hand, charcoal furnaces, especially when they are run on very lean slags, build up on the walls with that fusible but tough and stringy material. These slags are decidedly on the silica side of the most fusible slag, and by lightening the burden and adding an excess of lime for a day or two they may generally be scoured off completely. This I have done more than once.

THE DESCENT OF UNREDUCED MATERIAL INTO THE HEARTH

Obviously every time the furnace hangs and then slips we have a condition which deprives a part of the material of some of the time which it should have had for preparation in its descent through the furnace. But in the upper part of the shaft where we have the greatest surplus of heat and in general a surplus of reducing power, such a slip is not of much consequence unless it represents hanging for the space of an hour or more.

But as we go further down into the furnace the mar-

gins of heat and of reducing power are lower and lower, and the time in which to make up for treatment lost is smaller and smaller, so slips become not only more violent because of the higher pressure from which the furnace is relieved, but more serious, and their effect on the action in the hearth may be disastrous, especially if the shaking up which occurs at that time permits the ore to run ahead of the coke and come down into the hearth before the coke which should accompany it.

Obviously in this case we have material very inadequately prepared in the first place, and yet have no coke appropriated, so to say, to the purpose of finishing the smelting action of the furnace upon it, let alone supplying any deficiencies in reduction. The same is true in the case of the breaking off of a scaffold and the descent of its material into the hearth.

The Chilling of the Furnace

In all cases of chilling of the furnace we have an action which is serious in proportion to the amount of incompletely prepared material involved.

If this be small it may be taken up by that latent reserve of heat which the furnace seems to possess, without producing a very serious result. But a very moderate amount of material so precipitated into the hearth brings about a complete derangement, first: the incomplete reduction of the iron which passes into the cinder, turning it as black as tar; second: the cooling of the hearth with its resulting insufficient desulphurization and the ruin of whatever iron may be produced in consequence; third: insufficient heating of the slag and iron to permit their discharge from the furnace through the normal apertures in the proper way. Finally, the chilling of a heavy scull of iron, frequently low in carbon, around the whole interior of the hearth and the lower part of the bosh, making the task of drilling in to discharge either iron or cinder very difficult. This is quickly followed by the freezing of the iron in the lower part of the hearth so completely that it will not run no matter how far we may drill into the tapping hole, which is then "lost." This in turn is followed by the freezing up of the iron and cinder around the tuyeres until perhaps only one or two are left sufficiently open for a little blast to pass through. Meantime it having been impossible to withdraw anything from the furnace, and some blast going in continually, combustion continues and more slag continues to be formed, and in the greater quantity because a great percentage of all the iron also passes into it.

We have now a furnace containing many tons of molten material to a height perhaps several feet above the tuyeres, the bottom of the hearth solid with frozen iron in its toughest condition, and a scull of iron or steel all around the upper part of the hearth and the lower part of the bosh, which prevents our making any opening at the cinder notch for the withdrawal of the cinder which has accumulated. We know that we cannot go on indefinitely, that, for instance, the liquid pressure of the thin, violently active, scouring cinder inside the furnace increases the liability of its breaking out at some point, and the certainty that when it does so the running stream will cut almost anything that comes into its path, will run all over the ground and make access to the aperture almost impossible, and that if the engine fails this huge mass of slag will seek its own level in the penstocks and bustle pipe, and that if on top of present misery a slip occurs it will force the slag into the blow pipes and penstocks, even against the blast pressure.

When this condition is reached the furnace is technically said to be "in a mess." Any furnaceman who has ever passed through the experience will admit that

the term is literally as well as technically correct. If he be consulted at the time he will probably express an unfavorable opinion of a man with so little judgment as to enter a business capable of producing such horrible conditions.

These are also the conditions in a general way which result from other causes, a long stop without warning, a mistake in the filling by charging too little coke, a bad breakout followed by water running from the ditch through the hole made by the breakout into the hearth and standing there for hours because the breakout had effectually dammed the ditch, which I once experienced, and various others.

The question is what course must be pursued to restore those normal conditions which bring profit to the owner and comparative peace of mind to the operator and the crew.

A little consideration shows that no matter what the ultimate cause may have been, the immediate cause of the difficulty is the absence of sufficient heat to bring the materials in the hearth to the temperature at which they will run out, and if my description of the terrors of such a condition were adequate (which it is not), it would perhaps explain my tiresome insistence in earlier chapters on the free-running point as the critical temperature of the furnace and on the vital necessity of enough heat in the hearth to bring about this temperature.

The remedy is then to introduce more heat into the hearth. But our chief method of doing this is to introduce more fuel and we can in general only introduce this at the top of the furnace, and in order to permit its descent into the hearth all the charge in the furnace at the beginning of the trouble must be worked out. This requires from eight to twenty hours, depending on the rate of driving, even in normal operation, when all the molten material can be removed as formed, in a truly liquid condition; but when the furnace is in a "mess" the possibility of such regular removal has vanished, in fact, we might define a mess as any condition which made the free and regular removal of the molten material impossible.

We must then find means to carry on such removal as best we may until the blank of coke charged to give relief can reach the tuyeres, and this period is prolonged just about in proportion to the difficulty of slag and iron removal. For this reason the wise furnaceman when he sees signs of impending trouble, charges a good blank of coke knowing that even if it does not reach the hearth in time to avert serious trouble it will shorten by so much the weary interval of difficult and irregular flushing and casting.

If the mess arises through a breakout or mechanical breakdown, which causes a long and utterly unexpected stop, he charges the blank the first thing on starting up, and if the difficulty threatens to be a serious one he lightens the burden to a material extent so as to have a reserve of heat to overcome the irregular conditions which will probably persist long after the blank is gone and the furnace once more in operation.

Steps to Be Taken in the Early Stages of Chilling

The important question is, "What methods are to be used to remove the slag and iron after the regular methods fail?"

As the furnace loses its normal supply of hearth heat, the portion farthest from the tuyeres naturally feels the loss first and therefore the iron in the bottom of the hearth, where the regular tapping hole is, freezes so that no iron can be drawn from it; sometimes the drill simply encounters a mass of red hot tough pasty iron which it cannot penetrate, more rarely it goes half

across the furnace underneath the iron in a mass of brick, slag and heterogeneous material which can be drilled but which will neither run nor allow the iron to run.

In such a case the molten iron lies higher up and ordinarily other holes are drilled at successively higher levels until liquid iron is reached or it is found impossible to reach it.

In some rare cases a dry hole under the bottom of the scull in the hearth may be shot with dynamite and the scull broken through up into live iron above, which will then flow out. It must be remembered that the hole is between red and white hot and the radiation from it is sufficient to set off the dynamite in a few seconds so this operation is not to be regarded as a safe and harmless pastime. On the only occasion when I used this expedient the hole was drilled well back to the center of the furnace, so there was no danger of damage to the hearth jacket as there would be with a shallow hole; the dynamite was wrapped in rags soaked in thick grout and laid on a little wooden trough or boat so as to keep it from contact with the bottom of the hole; the fuse was cut to burn only a few seconds, it was lit after the charge was placed in the trough and the latter was quickly pushed down to the end of the hole with a long rod and all hands retired to a short distance without unnecessary delay, and waited until the explosion came. This was followed by a small river of iron and our troubles were over for that time.

Generally, however, no hole can be drilled at all at the bottom and it becomes necessary to go higher and higher to reach the iron. When the top of the iron notch opening through the hearth jacket is reached and still the scull around the hearth cannot be penetrated the tapping hole is "lost" and it is then necessary to go to the cinder notch.

Casting Through the Cinder Notch

The construction of the latter is excellently designed for the purpose for which it is normally used, the quick, easy and safe removal of the cinder. But while water-cooled bronze will withstand molten cinder of almost any temperature, it will not withstand molten iron at all, or, at least, it is likely to fail in a few seconds under a flow of iron, especially the raw, scouring and extremely corrosive material which is produced at such times.

The failure of the water-cooled bronze parts is certain to result in a violent explosion, and therefore before casting through the cinder notch the bronze cinder cooler must be removed. The monkey will probably have been "pulled" already on account of stiff, sluggish slag. If there be an outside iron cinder cooler it must take its chances because it cannot be "pulled." The danger of having this cut is much smaller, and bad explosions are not so likely to follow if it is, and whatever risk there may be is further reduced by making up a bed of sand or clay in the bottom of it. An emergency runner of sand is built from the cinder notch back into the iron trough if possible or else to the iron ladles or the pig beds.

One disagreeable consequence of casting through the cinder notch is that the iron cinder cooler, if there be one, or if not the brick surrounding the hole, are cut and roughened by the scouring mixture of iron and cinder, which is always to be expected under such conditions, and lumps of iron or cinder are left burnt onto the brick or the iron cooler as the case may be. The temporary bottom of sand brick or clay used to pave the bottom of the opening helps to prevent this, but the lining is likely to be knocked off, particularly on the side. These lumps are very difficult to remove when they do

become burnt on and unless they are removed the bronze cooler cannot be put back to its proper place. They are, therefore, very objectionable.

In order to protect the hole completely, I have used very successfully the expedient of inserting a piece of common wrought-steel pipe about the size of the inside of the bronze cooler and packing around the outside of it with clay. The pipe may burn up during the first cast through it, but usually lasts several. When burnt up it can readily be replaced, and when normal conditions are restored it can be pulled out and the clay packing of the pipe removed without difficulty, leaving the brickwork or the iron cooler, as the case may be, in perfect condition. This is a small matter, but it may save hours of work and injurious delay in getting back to normal operations.

When all the necessary arrangements have been made the next thing is to drill through the cinder notch if possible. When this can be done the furnace can be kept in fairly steady operation and the life-saving blank worked down to the tuyeres without undue delay, and the trouble is then likely to be pretty well over.

Opening a Chilled Hearth

But if the scull is too hard to drill and too rough to drive—then the real trouble begins. To force an opening we have now available four means, dynamite, the kerosene blowpipe, the electric arc and the oxygen burner.

DYNAMITE

If the hole has been drilled back well into the scull so that the latter shows red hot, then the hole can some-

times be shot open with dynamite. The charge should be made up in a cartridge made of a piece of pipe 2 in. or 3 in. in diameter and mounted on the end of a long piece of small pipe for a handle so that it can be set off instantly when the cartridge has been placed in the hole. This latter is not a particularly pleasant job because the dynamite may be exploded prematurely by the heat of the hole. There is, of course, no time for tamping and much of the force of the shot is lost, but by following up with larger cartridges as the hole swells the scull can sometimes be torn open.

I once saved by this means a furnace which had lost not only the tapping hole and the cinder notch, but also all the tuyeres but two. We shot open a "dead" tuyere, into which we had drilled as far as we could in trying to flush through that, its level was too high to give good drainage from the other tuyeres, but opening it removed a huge mass of molten and pasty material which had been held up in the bosh by the blast pressure. This gave us time to take further steps and really saved the day.

The closing of this hole was no joke; the drainage afforded was incomplete because only on a level with the tuyeres, so if the blast were taken clear off the cinder came back into our only two remaining tuyeres. Of course, with the blast on even very little the big hole which the destruction of the tuyere had left, discharged flame and shot cinder about like a small bessemer converter. We finally checked the blast with the snort valve to the point where the cinder was barely kept out of the tuyeres and reduced the discharge of flame and shot cinder to the point where one of our

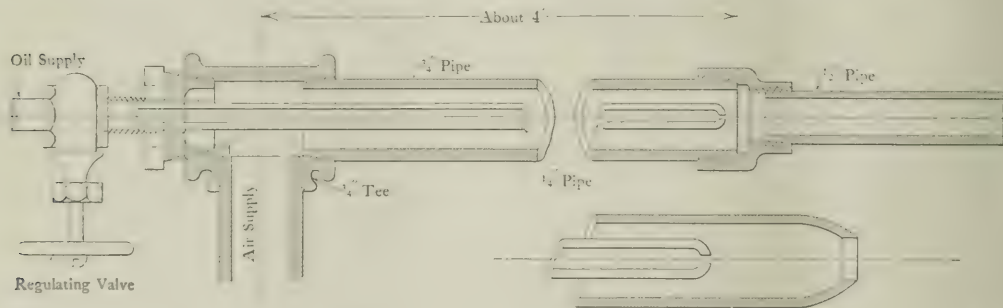


FIG. 1 - First and Correct Construction of Burner

FIG. 2 - First Improvement (?) Value Minus 50%

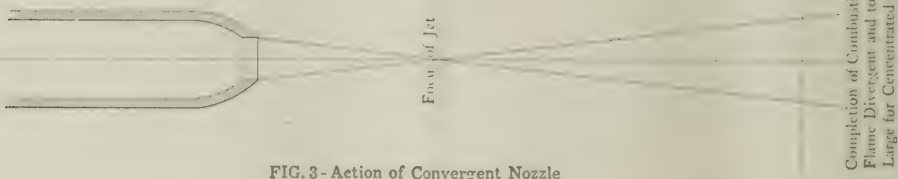


FIG. 3 - Action of Convergent Nozzle

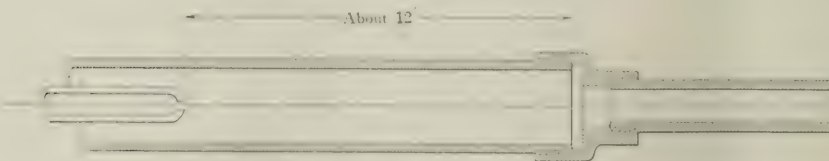


FIG. 4 - Second Improvement (?) Value Minus 100%

keepers volunteered to stop the hole, which he did with clay balls and a stopping hook. The job only took two or three minutes, but his overalls were practically burnt off him by cinder shot when he finished; it was one of the pluckiest acts I ever saw. Such details will perhaps help to give some idea of the conditions likely to arise during a mess.

The conditions under which dynamite can be used successfully are rare and its use is always highly undesirable because of dangers to which its use exposes the plant as well as the crew, and in consequence it is not often used.

THE KEROSENE BURNER

Probably the first means developed for meeting these conditions was the kerosene blow-pipe. Its use gives such very different results, according to its control, that it has been utterly condemned by some good furnacemen, while it was regarded as a life saver by others, before better means took its place.

Some experience with these blow-pipes and some of the principles on which their successful use depends were described in the *American Machinist* ten or twelve years ago and a portion of the article is quoted here.

The oil burners shown in Figs. 1, 2, 3 and 4 were made in great haste and in almost total ignorance of the details of their construction, as far as experience was concerned. A piece of $\frac{1}{4}$ -in. pipe was welded shut on one end and a $1/16$ -in. hole drilled through this end. On the other end of this pipe a long thread was cut, which was screwed into a bushing, filling the rear end of a $\frac{3}{4}$ -in. T. At the side of the $\frac{3}{4}$ -in. T the air entered through a nipple and hose. The $\frac{3}{4}$ -in. pipe in the front end of the T in the first burner made was about the same length as the $\frac{1}{4}$ -in. pipe inside (about 4 ft. long), and on its end was screwed a reducer, into the end of which a $\frac{1}{2}$ -in. nipple, about 4 in. long, was screwed.

This burner was very successful, though used under lighter air pressures than those we subsequently obtained, but having been the first one made, it was, perhaps, natural to think that subsequent ones should be better; so desiring another, the $\frac{3}{4}$ -in. pipe was drawn down by a smith to a conical end or jet much better looking than the reducer and $\frac{1}{2}$ -in. nipple, as shown in Fig. 2. But after full and fair trial, it was found impossible to get the concentration of heat in one place with this that was obtained with the other, for the reason that under the heavy pressure of air the velocity of efflux was so great that combustion was not complete until a point was reached something like $1\frac{1}{2}$ ft. beyond the end of the burner. With the conical nozzle the jet action had ceased, and the lines of flow of the flame had ceased to be convergent and had become divergent within less than a foot; consequently, the flame was without any accurate center, and was quite rapidly divergent at the point where combustion was complete and where the greatest heat should have been if it had been properly concentrated, all as shown by Fig. 3.

The $\frac{1}{2}$ -in. nozzle by permitting the flow to be approximately parallel, enabled the combustion to be complete within a small area at whatever distance from the burner might be necessary within reasonable limits, and, therefore, focused the activity of the flame much better than the convergent nozzle. This, at least, seemed to be the theory, and these certainly were the facts, as was clearly proven by cutting off the convergent nozzle and substituting for it the reducer and $\frac{1}{2}$ -in. nipple.

Another improvement, shown in Fig. 4, was attempted, with the object of heating the oil further by the action of the $\frac{3}{4}$ -in. pipe upon it before it reached the point of discharge. It should have been stated above that the oil was delivered by pipe and hose connection

from a barrel placed at the top of the furnace, some 70 ft. above, so that there was a very good head to drive it through the $1/16$ -in. hole, and a sufficient quantity emerged to make a very large flame. The quantity was regulated by a $\frac{1}{4}$ -in. globe valve on the projecting end of the $\frac{1}{4}$ -in. pipe, at whose inner end was the $1/16$ -in. orifice. The operator regulated the action of the blow-pipe by opening or closing this valve minute amounts to suit conditions, and also fed the nozzle or drew it back so as to keep the hottest part of the flame in the point where the melting was desired to take place. The improvement, which was attempted, consisted in cutting off the $\frac{1}{4}$ -in. pipe which carried the oil about 1 ft., so that the oil had to traverse about a foot of space through the $\frac{3}{4}$ -in. pipe before reaching the $\frac{1}{2}$ -in. nozzle, the idea being that it would in this way be preheated more than by simply passing through the $\frac{1}{4}$ -in. pipe for the same distance.

The attempt to operate this burner was most exasperating and unsatisfactory. If the valve were regulated to bring the flame to the right condition, it would sustain itself for a brief instant, go out, and be followed by a surplus of oil which re-ignited against the hot surface and made a detonating mixture with the air with which it had become mixed during the instant of extinction, so that virtually the action of the burner was no more than a series of sharp explosions at intervals of about a second, with, of course, no useful heating effect.

No regulating of the valve sufficed to cure this most objectionable condition, but finally close observation showed that coincidentally with the flashes of re-ignition there came a few drops of oil in liquid form, not spray, from the end of the $\frac{1}{2}$ -in. nipple. It was these which supplied the excess of combustible and made the smoky flame accompanying the explosions (which, of course, were perfectly harmless in their nature).

When this was seen the secret was out. The oil was not driven with sufficient force to throw it entirely into spray at the base of the $\frac{1}{2}$ -in. nozzle, but some of it ran down and along the bottom of the $\frac{3}{4}$ -in. pipe, whence it was picked up and carried in waves by the action so familiar to all in such cases, with the result that there was first an excess and then a deficiency of fuel for the air, the supply of which was constant.

A longer $\frac{1}{4}$ -in. oil pipe was at once procured, which delivered the oil just at the base of the $\frac{1}{2}$ -in. nozzle, where the high velocity of the air consequent on the reduction of area caught it and threw it into a perfect spray, so that the action was complete and continuous. This perhaps may be a useful experience for those who have to do with oil burners as a regular occupation.

Another point of much interest in connection with these oil burners came to light during the brief experience, of which mention has been made. This was that the burner did better the deeper the hole in which it was working. The reason was not very far to seek. When the hole was quite deep, say 2 ft., and of comparatively small diameter, the flame which, had it been unobstructed, would have gone perhaps 7 or 8 ft. beyond the end of the burner, was compelled, by striking the object of its attack, to return on its course and come back over the burner itself. The result would have been that the burner would have been heated to a white heat in a very few minutes had it been a piece of "dead" pipe of the same size in the same flame, but as a matter of fact the burners never showed the least inclination to get even red hot, being cooled by the rapid current of air through them. The other phase of this fact is that the air must have been heated before leaving the burner to a very considerable degree. One could even imagine that it may have been 500 or 600 deg. Fahr., though

naturally no effort was made to determine the amount at that time.

Just what the flame temperature in such a case is I do not know. Theoretically, it would probably be 3500 deg., or perhaps more, but actually would not likely be above 3000 deg. If, now, the fusion point of the substance to be melted were 2500 deg., then an increase of 500 deg. in the temperature of the air, giving an increased flame temperature of perhaps 400 deg., would make the latter 3400 deg. instead of 3000 deg.; and while this is not a very great difference absolutely or relatively, based on the total temperature, when compared with the fusion temperature (assumed to be 2500 deg.), it is seen to be almost twice as great a difference, implying twice as much heat available for melting operations, as well as nearly twice the "thermal head" for causing the heat to flow from the flame to the object being melted. Moreover, it is almost certain that the oil inside of the $\frac{1}{4}$ -in. pipe was somewhat preheated also, and, therefore, its vaporization at its exit from this pipe was much quicker and more complete.

Much larger oil burners are sometimes used, in some cases a 2-in. pipe for air and a $\frac{1}{2}$ -in. pipe for oil, and in some cases no nozzle is used because it melts away in the intense heat developed, the pipes simply discharging through their open ends.

The necessity of having the focus of the jet coincide with the zone of complete combustion has been shown by all my observations, and it is this fact which makes it so difficult to secure the best results with these burners, because we have four variables to regulate; the distance of the nozzle from the surface to be fused, the velocity of the jet depending on the pressure of the air at the nozzle, and the quantity of air depending on the size of the pipe as well as the pressure, and the quantity of oil.

The fact that the volume of air and its velocity which should vary independently, must actually vary simultaneously, is perhaps one of the greatest difficulties. Sometimes it seems impossible for one man to obtain a satisfactory adjustment of all these variables when another will have no difficulty. On one occasion my assistant, the master mechanic, and I all failed to do any good with one of these burners, but the colored pipe fitter came along and did good work with it.

One vital fact to remember is that the best fuel for generating heat to melt iron is the iron itself, not only because of the heat it develops, but because the iron oxide slag formed as a result melts at a much lower temperature than iron. For this reason no burner ever works successfully except with an oxidizing flame. A reducing flame makes a pretty sight and a lot of light, but does no good whatever, whereas an oxidizing flame, making a hideous roar and showing only a short blue flame, will really cut. After the point of attack is heated to the proper temperature the supply of oil should be reduced to the minimum so as to leave as much oxygen as possible free to burn the iron.

Later and far better methods of burning open-chilled top cinder notches and the like have laid the kerosene burner on the shelf for most conditions, but for isolated plants caught in a mess without the modern apparatus they are not to be despised.

THE ELECTRIC ARC

Heat developed by electricity differs in one important respect from heat developed by combustion. Its temperature of application is virtually unlimited, from the industrial point of view at least, while we have seen the rapid increase in limitation to combustion heat, which rise of temperature causes. Electric heat has then an increasing advantage as the temperature of application

rises and this is, of course, greater in fields where the actual amount of heat required is small.

These conditions are exactly those of melting out a frozen cinder notch or tapping hole.

Nearly all blast furnace plants of importance have an electric plant of some size and very early in the present century it was found that the electric arc could be used in such cases with tremendous advantage, and the practice rapidly spread.

The chief consideration next to having sufficient energy available is that the voltage shall be low. In the description of the removal of the salamander in a previous article, the reasons for this are given and need not be repeated here. The voltage preferred for this service is about 50 and at least 1000 amperes should be at hand. Twice as much is better. This gives a short controllable arc and the melting can be done where it is needed.

Alternating current has the great advantage for this service that the approximate voltage needed can be obtained directly from suitable transformer, whereas direct current must be choked down in voltage through a water rheostat or some equivalent. This is not only wasteful of power, but the apparatus is clumsy and the control not easy. At one large plant a transformer of suitable size and design was located permanently at each furnace so that it was only necessary to place the carbon and turn on the current. A hole can be burnt in a short time into any place where there is enough conductivity to carry the current.

THE OXYGEN BURNER

Modern progress has brought into common use the oxyhydrogen and oxyacetylene blow pipe and developed comparatively cheap methods of producing the gases so that the use of these means for cutting iron and steel as well as that of oxyacetylene for welding is growing at an exceedingly rapid rate. Carloads of oxygen cylinders are now more common than single ones were not long ago. The application of this apparatus to frozen cinder notches, etc., was obvious, and it has now come commonly to be preferred to the arc, although the latter continues to be used.

The preferred practice is to use the blow pipe only to bring the surface to be burned up to the temperature at which it will burn in pure oxygen and then direct a stream of the latter against it under heavy pressure. The reflex velocity of the jet keeps the hole clear of the burnt iron formed and rapid action is maintained.

The results which can be obtained in this way are little short of marvelous, instead of being a matter of hours to burn through a few inches of iron as is the case with the oil burner, it is a matter of a very few minutes. In one case of which I knew, a badly frozen tapping hole was burned through and the iron running in about 6 minutes from the time the oxygen jet was turned on. With the great increase in the ease of obtaining oxygen quickly and cheaply, this process seems likely to supersede all the others. It and the electric burner together have done much to remove the terrors which a chilled furnace formerly held for the unfortunate furnaceman.

ADDING ADDITIONAL FUEL IN THE HEARTH

In the most extreme cases of chilled furnaces the material in the hearth is so chilled that the blast has but little effect, in fact, can practically not penetrate the frozen material enough to generate any heat or form any slag. In such cases the materials in the hearth are dry rather than pasty, and can be removed through the tuyeres and cinder notch by pulling out solid lumps of coke, ore and limestone.

In such cases the preferred procedure is to dig a considerable hole into the cinder notch and into the tuyere nearest to it, fill up this space with fresh lumps of coke put in from the outside, then put back the blow pipe into the tuyere. If necessary, kindling or a piece of waste is used to ignite the coke as in blowing in.

A small quantity of blast is then put on; this passes through the coke and burns out the cinder notch, thereby establishing good communication between these two and enlarging the cavity. The furnace is then stopped and the next tuyere is then treated in the same way, and by blowing through this communication from it also is established with the cinder notch. In this way, if need be, one tuyere after another can have re-established its communication with the others and with the cinder notch, while much heat is added by the combustion of the coke put into the tuyeres.

Personally, I have never had to fight a furnace that was so badly bungled up as this, but the process has been used by experienced furnacemen who have described it to me.

Another expedient which is well recommended by those who have used it but which I have never tried, is the use of kerosene in the tuyere itself.

A small pipe is put through the peep-hole in the elbow of the penstock and run practically to the inner end of the tuyere. This is supplied with kerosene under pressure from a tank above and the blast turned on. This converts the whole tuyere into a gigantic blow pipe and permits imparting to the furnace a great amount of heat at the point where it is most needed. In this case also, if the bosh is too completely chilled to permit of passage of gas formed an outlet must be made through the cinder notch or perhaps through another tuyere, as in the previous case.

The details of these operations necessarily vary almost infinitely according to the judgment of the operator and conditions to be met. It is therefore impossible to describe them in detail, but the general outline of the operations is as described.

A Method of Exhibiting the Velocity of Iodine Ions in Solution *

BY S. W. J. SMITH

The apparatus is represented in the diagram. The containing vessel is a U-tube with widened ends as shown. The diameter of the tube may be about 0.5 cm. or less. The cross-section of the tube should be fairly uniform. Either 25 cm. or 50 cm. is a convenient (total) length for the tube if it is desired to use it in connection with an ordinary lighting-circuit voltage of 100, or thereabouts, and to obtain a rapid estimate of the velocity of the ions. The electrodes (at A and B) are, preferably, of platinum foil. The liquids used are equally concentrated solutions, containing—e.g., either 0.2 gm. or 0.1 gm. mol. per liter of potassium chloride and potassium iodide respectively. The novelty of the experiment lies in the method of exhibiting the line of separation between the solutions. For this purpose a small quantity of mercuric chloride (corrosive sublimate) is dissolved along with the KCl. In the endeavor to main-

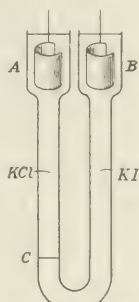


FIG. 1—ARRANGEMENT OF APPARATUS

tain symmetry an equal quantity of the same salt may be added to the KI.

In this case a thick yellow disc of mercuric iodide, precipitated by the action of the KI upon the $HgCl_2$ contained by the KCl, will appear at the junction between the electrolytes.

The electrodes at A and B are connected to the source of supply, that at A being made the anode. The boundary at C immediately begins to move upwards. It travels as an extremely thin horizontal disc, which can be located very accurately and projected with ease. And the disc will move at speeds of the order of 1 mm. per minute, so that its motion can be followed without difficulty by a large audience, and an approximate estimate of its velocity can be obtained in a few minutes.

A table giving the results of an experiment then follows, and it is remarked that the possibility of observing the reverse motion of the ions is due to the yellow coloration produced by chlorine ions which decompose a fraction of KI.

The solution contained 0.2 gm. mol. per liter. In an experiment made to obtain an estimate of velocity under the potential gradient of 1 volt per centimeter at a definite temperature, the distance traversed by the line of separation during the first half hour of the experiment (measured by means of a small cathetometer) was 4.13 cm. The distance traversed in the second half hour was 4.53 cm. The difference was probably due mainly to a higher mean temperature in the second half of the experiment. On this occasion an ammeter was included in the circuit. The reading rose slowly during the observations. Its mean value during the hour was 0.02 ampere. The specific resistance of the electrolytes was measured at 10 deg. C. (the temperature of the room) just before the tube was filled. The mean value was approximately 55 cm. ohms. The value of the current immediately after the circuit was completed was 0.023 ampere. The area of cross-section of the tube was about 0.31 sq. cm. Hence the initial potential gradient in the tube was approximately 4.1 volts per centimeter, and the velocity of the anions, iodine and chlorine, as determined in this way, is about 0.00059 at 25 deg. C. in cm. per sec. per volt per cm. If accurate and not rapid determinations were required much smaller potential gradients could be employed.

The author concludes by referring to the solutions used, and their conductivities and concentrations. It is also mentioned that a small quantity of $AgNO_3$ might be added to the KCl solution, and redissolving the precipitate by NH_4OH . The AgI formed during the experiment being insoluble in NH_4OH then acts as an indicator, and the progress of the ions may be watched as before. It is found, however, that this method is not so satisfactory as the one mentioned above.

Future Rubber Output.—From a statement issued by the B. F. Goodrich Co., Akron, Ohio, the prospective rubber output is as follows for years up to 1921. Past production back to 1905 is also given.

Year	Production, Tons	N. E. A. Tons	P. E. Tons
1905	187	60	60
1906	1,000	68	60
1907	1,000	68	60
1908	1,000	68	60
1909	1,000	68	60
1910	1,000	68	60
1911	1,000	68	60
1912	1,000	68	60
1913	1,000	68	60
1914	1,000	68	60
1915	1,000	68	60
1916	1,000	68	60
1917	1,000	68	60
1918	1,000	68	60
1919	1,000	68	60
1920	1,000	68	60
1921	1,000	68	60

The significant feature of this table is the greatly increased growth of cultivated rubber on plantations.

*An abstract of a paper read before the Physical Society of London. From *London Electrician*, May 26, 1916, p. 255.

Ethyl Alcohol from Wood

The Process, Its Development and Requirements

BY F. W. KRESSMANN

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Madison, Wis.

The European war has caused a large number of industrial changes in this country in the last year. Many industries which several years ago were in a depressed condition are now operating at capacity and in many the capacity is being increased as rapidly as building operations and manufacturing of apparatus will permit.

The alcohol producers of the country have felt this change. The ethyl alcohol or industrial distillers had felt the prohibition movement and the wood alcohol market was barely holding its own because of the generally depressed condition of the hardwood destructive distillation industry, especially the acetate of lime end of it.

Now all this is changed, the ethyl alcohol business is enjoying an unprecedented prosperity and many old distilleries that had not operated in years are working at full capacity and several very large new distilleries have been built. In fact, the industry was contracted up to such an extent that an order for 2,000,000 gallons of 95 per cent alcohol for immediate regular delivery went begging for some time.

Because of this greatly enhanced value of alcohol for war purposes and because of the tremendous and alarming increase in the cost of gasoline, the production of ethyl (grain) alcohol from wood should receive the undivided attention of the large sawmill operators and other producers of wood waste. For this reason a brief history of the production of ethyl alcohol from wood, especially as the process has been developed in this country, along with a description of the process, plant requirement, and estimated cost of production, we believe, will be of particular interest at the present time.

For, in addition to the foregoing factors, a number of others may be mentioned that would operate in favor of wood as against grain and molasses for the production of alcohol. The war, of course, has increased the value of grains which has made itself felt in turn in the cost of ethyl alcohol from grain. Much of the molasses distilled is imported from Cuba, Porto Rico and Hawaii. The price of molasses has increased because of great increases in ocean freight rates; in Hawaii, for instance, large quantities are being burned to recover the potash in the ash, the molasses being worth over \$15 per ton for its potassium content alone.

Corn yields about 2.4 gallons of 190 proof alcohol per bushel, and although the price of corn has varied considerably,* both seasonally and annually, and especially in the last few years due to the war, the average cost of the materials used for making grain alcohol (fuel excluded) is about \$0.275 per 190 proof gallon. The manufacturing cost, including coal, interest, repairs, depreciation, taxes, labor, etc., ranges from \$0.10 to \$0.17 per gallon of 190 proof alcohol, depending upon the location and efficiency of the plant. This makes a total of from \$0.37 to 0.44 per gallon, which is greater than the price of denatured alcohol or of ethyl alcohol for denaturing purposes before the war. The reason for this is that the grade of alcohol used for denaturing purposes is not as high as the best that can be produced from grain.

The better grades, which have been redistilled a number of times, and also passed through charcoal, usually command a sufficient premium so as to make up the deficit incurred in the production of alcohol of a denaturing grade. In addition, the above figures apply more particularly to the production of alcohol which is later sold in the form of whiskey and in which a higher quality of grain is necessary than in the production of straight alcohol. It may safely be assumed, however, that the cost of production of alcohol even from condemned grain varies between \$0.25 and \$0.35 per gallon.

One gallon of molasses yields from 0.45 to 0.48 gallon of 190 proof spirit. The price of molasses has averaged from \$0.05 to \$0.075 per gallon, although since the war, and particularly on the west coast, quotations on molasses have gone up as high as \$0.10 per gallon. So that the cost of raw material in a gallon of molasses spirit has averaged from \$0.10 to \$0.15 per gallon, although at the present time it may be nearer \$0.20 per gallon. The cost of production of molasses spirit is slightly less than that of grain spirit, but in either case we have a comparatively high cost of raw material.

One ton of dry coniferous sawdust or other form of waste (or its equivalent on an air-dry or green basis) will yield from 15 to 25 gallons of 190 proof spirit. This material in the vicinity of a sawmill or other large wood working plants is, in some cases, an item of loss, since most of the mills produce waste in excess of their own power requirement. In other cases it is not worth more than \$0.30 to \$0.50 per ton, which, therefore, makes the price of raw material in a gallon of ethyl alcohol from sawdust about \$0.02. This also includes a fuel charge, since the residue after conversion and extraction is available for fuel, whereas in grain and molasses distilleries about seven tons of coal are required per thousand gallons of 190 proof spirit. In grain distilleries, however, the still slops which contain all of the protein and nitrogen that was in the grain are recovered and used for cattle foods, either in feeding pens in connection with the distillery or else are dried and sold as such. This forms a valuable by-product which is not obtained in distilleries operating either on wood or on molasses.

If the manufacturing costs of producing ethyl alcohol from wood can be reduced to a figure approximately the same as the cost of production from grain or molasses, we have a large margin in the cost of raw material in favor of the alcohol from wood waste. Of course, if we compare a yield of 20 gallons to the ton from wood to 80 gallons per ton from corn, we see that the amount of material handled in certain parts of the plant producing alcohol from wood will be four times as great as in a grain distillery of equal capacity, thereby increasing the size of the plant and operating costs. The fermenter and still equipment, however, will not need to be larger than in a grain distillery of equal capacity, so that one of the largest items in the production of alcohol has not been increased.

In recent years the production of ethyl alcohol from sawdust has received a great deal of attention and a great deal of money and effort have been spent in its technical development. A number of plants have been built in this country, but one only of them has, up to the present, been considered a commercial success. Because of the importance of the problem of waste disposal to the lumber industry and because of the adaptability of this process to the disposal of coniferous wood waste in quantity, the Forest Service has investigated both the process and, as far as possi-

*The price of grain increased in 1918. According to the Chicago Board of Trade, the average price of No. 2 yellow corn, 1913-1914, ranged from 19¢ to 21¢ per bushel.

ble, the plants that have been built in an effort to determine the causes for failure and to aid in its development to a commercial success.

Outline of Processes

The processes used for the production of ethyl alcohol from wood may be grouped into two general classes—first, the hydrolysis or conversion of the wood into fermentable sugars by the use of dilute mineral acid as a catalyst; and second, solution processes in which the wood is dissolved from concentrated acid with a subsequent hydrolysis or conversion of the diluted solution.

Processes of the second class involving the use of concentrated sulphuric acid in which the wood is actually dissolved have not received commercial attention because the amounts of acid used have been so large compared to the processes in which the acid is used merely as a catalytic agent that the large initial and recovery cost for acid have prevented commercial development.

The first process of producing ethyl alcohol from wood consists in general of digesting the sawdust, or hogged and shredded waste, with dilute sulphuric acid at a steam pressure of 60 pounds or more for a short time. This is done in rotary digesters which will thoroughly mix the acid and wood. These digesters are of steel boiler plate with an acid proof lining. A part of the wood is converted into a mixture of sugars, some of which are fermentable. The digested material is next transferred to a diffusion battery similar to that used in the extraction of sugar from sugar beets or dyes from dyewood, and here the sugar and other water-soluble material is extracted with hot water from the digested sawdust. The acidity of the extract is then neutralized with lime or limestone, and the sludge formed by the calcium sulphate and some of the dust carried in the extract is allowed to settle out, which requires ordinarily from 15 to 20 hours. The clear solutions are then drained off and cooled to the proper temperature for fermentation. The fermentation, distillation and rectification of the alcohol are accomplished in the usual manner very similar to the production of alcohol from molasses.

History

The first recorded attempts to produce sugar and alcohol from vegetable fiber were those of Braconnot in 1819. From that time on at numerous intervals other work was published and a number of experimental plants were built, although all of them resulted in failure. This was because the scientific basis for the process had not been worked out. In 1898 Simonsen published the results of his research on the subject, in which he investigated both sulphite cellulose and sawdust in a systematic way. As the hydrolyzing agent he used sulphuric acid and from his results concluded that the best conditions for the inversion of sawdust were as follows:

Time of cooking	1 hour
Acidity	0.5 percent sulphuric acid
Proportion of wood to dilute acid	1 to 4
Cooking pressure	3 atmospheres

The above conditions gave him a yield of alcohol equal to about 6 per cent of the dry weight of wood used. Simonsen, however, made but few fermentation experiments, and therein his work was scientifically weak. A small plant was built in Christiania, but did not work out successfully, chiefly for the reason that such a large volume of dilute acid was used which required an excessive amount of steam to heat the charge and which later gave them liquors which were too dilute to distill economically. A number

of other workers checked Simonsen's work from the scientific standpoint and showed that in general the yields he claimed could be obtained.

Some time later A. C. Classen developed a process in which sulphur dioxide was used as the hydrolyzing agent. Classen took out a number of patents covering the various phases of his process in which both gaseous sulphur dioxide and also the gas dissolved in water to form sulphurous acid were used. This process is of particular interest since it was the beginning of the American development of the production of ethyl alcohol from wood, when in 1903 the patent rights for America were acquired by a Chicago company. This company erected an experimental plant at Highland Park, Chicago, and after demonstrating the process to their satisfaction erected a plant at Hattiesburg, Mississippi, at a cost of about \$250,000 to operate on longleaf pine sawmill waste.

This plant was a failure because of a number of mechanical and technical reasons, the chief of which are as follows: First, the length of time necessary to hydrolyze the wood, this requiring from four to six hours; second, the quantity of acid needed; third, the prolonged action of so much acid and water in the rotating digester reduced the wood to a very fine powder and formed much sulphuric acid, which acted on the sugar and other substances present to form gums and caramels and so made the complete extraction of the sugars from the residue very tedious and expensive; fourth, the digester was lead lined and the buckling and breaking of the lining necessitated repairs after every two or three cooks, which proved a great source of delay and expense.

Ewen and Tomlinson, who were associated with the Classen process, began experimenting along new lines in order to overcome the difficulties which were brought out at Hattiesburg. Instead of using an aqueous solution of sulphur dioxide, the gas was passed into the digester along with steam, which furnished, therefore, both the heat and moisture required.

Somewhat later, however, Ewen and Tomlinson gave up the use of sulphur dioxide and were granted a patent covering the use of sulphuric acid as the catalytic agent. A study of this patent and the process patented about 15 years previously by Simonsen will disclose a remarkable identity as to ideas.

Ewen and Tomlinson, who were then the engineers and technical advisers of an alcohol company, erected a plant at Georgetown, South Carolina, for the demonstration of their process. This plant was later acquired by a powder company, which has operated it intermittently for the last three or four years. The sawmill in connection with the alcohol plant burned down in 1913 and was replaced by a large new mill, which was put into operation about a year later. During this interval the powder company devoted a considerable amount of time and money to research on this problem.

Several years ago western capital erected a plant at Port Haddlock, Washington, on Puget Sound, for the production of ethyl alcohol and cattle food from sawdust obtained from mills at Seattle, Tacoma, Everett, Anacortes and Port Blakely. The plant was equipped with six digesters of the same size and type as those that were developed in France by the Compagnie Industrielle des Alcool de l'Ardeche. These digesters consisted of a steel cylinder 2½ meters in internal diameter by 21.3 meters in length, through which were spaced 22 tubes 160 millimeters in diameter.

Outside of each end of the tube heads are flanged boiler steel jackets, one to receive the live steam from the boiler and the other to take off the condensed steam, the heating being indirect, the idea being to save steam by means of the indirect heating. Sawdust and enough water were added through a man-hole into the space between the tubes to raise the moisture content to about 45 per cent. Anhydrous sulphur dioxide was then added and the mixture was cooked at 75 to 100 pounds pressure.

The cost of conversion was excessive because of the very rapid corrosion of the digesters, the long time necessary to heat indirectly and because the sulphurous acid gas leaked from the digester into the steam space, thereby preventing the use of the low pressure steam. In addition, the extraction equipment was inefficient and out of date. The buildings of the plant were excellent and expensive and much of the equipment was imported from France at a large cost.

The extracted sawdust (which had only from 50 to 60 per cent of the sugar formed extracted from it) was mixed with Hawaiian molasses and was put on the market as a cattle food. It was necessary to dry the extracted material down to about 12 per cent moisture in order to prevent decay and this gave great difficulty due to explosions of dust in the dryers. In addition, the plant was located about 80 miles from a railroad, which greatly increased transportation charges, and these facts, coupled with the very poor design and equipment (especially digester and extraction equipment), were no doubt the prime reasons which caused the failure at this plant.

After disposing of the Georgetown plant to the powder company the alcohol company referred to above underwent a reorganization. A large amount of foreign capital was introduced and a large plant designed to produce 5000 gallons of 190 proof alcohol per day was erected at Fullerton, Louisiana. This plant, to our knowledge, has never operated at capacity or even continuously for any length of time. The plant appears to have cost much more than it should. Even at present it is questionable as to whether or not a number of the units in it are of the size and type to secure maximum efficiency. Because of the fact that the plant was built largely with foreign capital the war has interfered with changes that are necessary and advisable before resuming operation, and the plant has been idle for a very considerable period of its existence.

This short outline is merely a review of the four plants that have been built in this country, only one of which has achieved any measure of commercial success, and does not take into account the very large amount of scientific work that has been done in the last decade and which will be covered fully in a later bulletin to be issued by the Department of Agriculture. The powder company, through its development department, and especially by the work of its superintendent and chemist at Georgetown, has really attempted to investigate the problem in a scientific way. Some of the other plants, especially the one in the West, were built by men without full knowledge of the requirements of an operation of this type, and apparently no technical supervision was obtained to assist and direct the work.

As long as the development of this process, which requires the highest type of engineering and chemical skill, is left in the hands of concerns interested chiefly in the disposal of stock the production of ethyl alcohol from wood will be costly to those who invest in it. In view of these facts the following

outline of plant equipment and operation with cost estimates has been prepared so as to present to the lumberman the actual requirements of an industry of this type.

Plant Requirements

The essential parts of a plant necessary to produce ethyl alcohol from wood considered in the order of their use are the following:

1. Adequate sawdust storage.
2. Disintegrating equipment { Hogs.
Screens.
Shredders.
3. Sawdust storage above digesters.
Acid storage.
4. Digesters.
5. Diffusion battery.
6. Neutralizing and settling tanks.
7. Coolers.
8. Fermenters and yeast equipment.*
9. Beer still.*
10. Rectifying still.*
11. Bonded warehouse.*
12. Boilers and engines.
13. Laboratory and office.

*These items must be under U. S. Int. Rev. Dept. approval and supervision.

SAWDUST STORAGE

Adequate sawdust storage will vary with the location and continuity of operation, the sawmill, and the character of the logging operation. The operation of the alcohol plant and distillery must be continuous. The storage must be sufficient to permit compliance with the necessary regulations of the Internal Revenue Department regarding the operation of distilleries. The latter are surveyed as to their output and must produce daily the amount required in this survey or else are penalized with the tax on such a quantity of alcohol as is necessary to make up the survey.

In general, therefore, the alcohol plant should have at least a 15-days' supply of wood on hand and, where logging operations are such as to require frequent shut-downs, the alcohol plant should have sufficient material in storage to last twice as long as the usual shut-downs. The waste can be stored and handled easiest in the condition ready for use, that is, hogged and shredded. Protection from the rain is sufficient and any type of open, walled, but covered building would answer the purpose.

Belt conveyers can be used to handle the material and a long open covered shed, with an inclined bottom sloping into a trough, similar to those used for the storage of sugar beets would answer the purpose.

DISINTEGRATING EQUIPMENT

This would consist of hogs or chippers and shredders and screens. A chip $\frac{1}{2}$ in. long with the grain will be penetrated thoroughly with acid, but the ease with which the sugar can be leached out is a problem that would require attention. However, since the residual digested sawdust or waste left after extraction is ample for power production, and all engine exhaust steam can be used for heating and distillation purposes, the extra power required to chip down a $\frac{3}{16}$ or $\frac{1}{4}$ -in. chip would not be prohibitive and the greater efficiency of extraction would probably make it very desirable. After screening and reshredding the screenings the fine stuff would go by belt to the loading bins over the digester.

SAWDUST AND ACID STORAGE

The loading bins should be of sufficient size to act as an intermediate storage for the material as it comes

from the screen on its way to the digester. They should hold four or five digesters full each and should be placed over the digester and tapered down so that the material can flow directly into the digester similar to those in use in chemical pulp plants.

The acid would come to the plant in concentrated form so as to permit tank-car shipment and storage in steel tanks. The concentrated acid would be pumped into a lead-lined tank above the digester and diluted so that the dilute acid could flow into the digester along with the sawdust. If rotating digesters are used no special mixing apparatus will be necessary, at least we have never found evidence of appreciable quantities of uncooked material when handled in this way.

THE DIGESTERS

The digesters should be rotating and may be spherical or short and cylindrical with dished ends. If the latter type is used the diameter should be double the length of the cylindrical section so that it may be filled as completely as possible. A number of satisfactory acid-proof linings are obtainable at present. During cooking the mass shrinks in volume and settles so that the final volume is only about two-thirds the original volume and leaves ample room for thorough mixing during cooking.

The sizes of the digesters will be governed by the daily capacity of the plant, the heating period and the time of the complete cooking cycle per digester. If the heating period is 15 minutes out of a total of 1 hour for each cook, four digesters, or multiples of four, should be used, whereas if the heating period is 20 minutes out of a total of 1 hour only three or multiples of three should be used. In this way the steam load on the boilers will be as uniform as possible and the boiler capacity will be dictated largely by this load, since the rest of the load for power and distillation purposes will be generally constant. In addition, the hogging, shredding and digester capacity of the plant should be such that it will give sufficient digested sawdust in 18 or 20 hours to run the rest of the plant 24 hours, thereby giving time for repairs and breakdowns.

The cooked sawdust can be discharged merely by rotating the digester and falls into a bin which receives the cooked material from all the digesters and from which it goes by a mechanical conveyor to the different cells of the diffusion battery.

DIFFUSION BATTERY

Closed cells similar to those used for the extraction of sugar beets or dyewood chips can be used. These should be lined so as to be acid resistant like the digesters and the top and bottom should be arranged so that charging and discharging can be readily accomplished. Cells of this type can be obtained in which the extracted material will empty itself after a release of the bottom of the cell. The temperature of the extracting water should be from 75 to 90 deg. C., since this will give not only a greater solubility than colder water but will also sterilize it and will keep the juice sterile while it is settling after neutralization.

The size of the cells and the number of cells in the battery and the amount of water per cell will be governed by the size of the plant and the size of the material that is cooked, since sawdust, for instance, will extract more readily than larger material. As our leaching experiments have shown, seven or eight extractions seem to be necessary; this would require eight or nine cells in the battery, since one is being discharged and filled all the time. Since the sugars are readily soluble, only a short extraction period is necessary, that is, from 5 to 10 minutes on each cell, or a total extraction period of from 50 to 75 minutes. This time, how-

ever, will be governed in part by the length of time that it takes the water to drain through each cell, which in turn depends on the size of the cell. The cells should not be too large, or the extracting water will not pass through the material easily, and the amount of water used should be such that the resulting extract is of the proper concentration for fermentation, which is from 11 to 12 deg. Brix. The Brix will go up another degree on neutralization.

Just as in the case of laboratory extractions, or washing of precipitates, a large number of extractions or washings with small amounts of liquid will give a better extraction or more thorough washing, and a more concentrated extract, than fewer extractions with larger amounts of extracting water for each extraction.

NEUTRALIZATION AND SETTLING

After extraction the acid extract is nearly neutralized with solid or milk lime or a high grade limestone (a magnesia stone is undesirable) and is then allowed to stand so as to settle out the sludge of calcium sulphate. This usually requires from fifteen to eighteen hours so that adequate tank capacity is required here.

COOLERS

The clear juice is then drawn off and passed through coolers to reduce its temperature to about 27 deg. C., from which it goes into the fermenting tanks. The coolers should be of copper and their size will depend upon the temperature of the water supply available.

FERMENTATION, DISTILLATION, ETC.

A 96-hour fermentation period is permitted, so that a four-day fermenter capacity is required. The size of the individual fermenter will be dictated largely by local conditions, such as mean temperature, and the other equipment is the standard distillery equipment in use at present in grain or molasses distilleries.

POWER REQUIREMENTS

The steam load of the plant will be distributed about as follows:

	Per Cent
Pumps	20
Boiler	20
Fire	20
General water supply	20
Beer	20
Alcohol	20
Digesters	20
Hogs and shredders	20
General power from driving conveyors, digesters, etc.	15
Distillation and rectification	15*

*Including all exhaust steam not used for heating boiler feed and extraction water. If large quantities of exhaust are not available, distillation and rectification may require as high as 40 per cent of the total load.

A large supply of pure cool water is necessary. It should be pure for boiler and extraction use and should be cool for use in cooling and condensing. The disposal of the beer still slops requires attention because of the large amount of pentose carbohydrate, and also of dead yeast which is highly nitrogenous and which would lead to rapid putrefaction.

COSTS

The production of alcohol by this process has up to the present time with possibly one exception, as outlined before, not been a commercial success. With new developments at the Forest Products Laboratory, allowing the necessary manufacturing losses involved in extraction, in the sludge of the settled juice, and in distillation and rectification losses, which combined should not be 20 per cent of the total yields, a yield of over 20 gal. per dry ton has been obtained.

Assuming this yield and a location where the supply of waste is uniform and constant for a period of twenty years and where plenty of good water may be had, and

where there is a fairly close supply of sulphuric acid and lime, the cost of alcohol from wood in a properly designed and constructed plant of 2500 or 3000 gal. per day capacity, is estimated per gallon of 190 proof as stated in Table I.

TABLE I

Yeast nutrients	\$0.015 to \$0.020*
Repairs and materials (exclusive fuel and wood) ..	0.030 to 0.040
Labor	0.015 to 0.030
Wood and fuel	0.020 to 0.030
Interest at 7 per cent.	0.019 to 0.029
Depreciation at 10 per cent.	0.023 to 0.035
Overhead, taxes, etc.	0.015 to 0.030
Total	\$0.137 to \$0.195

*This item may go as high as \$0.035 in some sections since the war, also rapidly advancing prices of iron, steel and copper. Particularly the latter, will require some increase in the above estimate, which was figured for market conditions existing over a year ago.

In Table I wood has been valued at \$0.40 per cord of 1800 lb. of dry wood per cord. This should consist of sawdust and hogged refuse but should not contain over 10 per cent of bark, since the yield of sugars and alcohol from bark is very low. A large quantity of bark would mean running a large volume of inert material through the alcohol plant at considerable expense without return and in the case of most barks would add large quantities of undesirable tannin to the solutions to be fermented.

Before the war alcohol for denaturing purposes could be obtained in quantity for \$0.30 per 188 to 190 proof gal.; at present (June, 1916) the market value runs as high as \$0.67 per gallon for small lots with, no doubt, appreciable shading for contracts in quantity. The price, however, has gone up from 33 1/3 to 50 per cent and as long as the war continues no appreciable decrease in price seems probable because of the demands for grain and molasses for other purposes and because of the enormous amounts of alcohol being used. Before the war from 10,000,000 to 11,000,000 gal. of denatured alcohol were being produced annually. This production has now increased to over 30,000,000 gal.

Under normal operating conditions most mills, particularly the large ones, produce waste in excess of their own power requirements and in large mills equipped with efficient power plants this excess will be from 50 to 65 per cent of the total produced. The disposal of this waste by means of a burner is, therefore, almost invariably necessary. The cost of burning this waste varies widely with the size and efficiency of the mill, but from figures gathered by this laboratory this expense ranges from \$0.30 to \$0.66 per cord, or from \$0.11 to \$0.22 per 1000 ft. on all of the lumber cut, and means that the present cost of waste disposal amounts to about \$6,000,000 annually, in addition to the value of the wood so burned.

All waste, therefore, that could be disposed of for the production of alcohol would not only net the sawmill about \$0.40 per cord but would also relieve them of the charge of burning which, as given above, ranges from \$0.30 to \$0.66 per cord and which, therefore, practically doubles the above realization to the sawmill.

In other words, an operation of this kind in conjunction with the sawmill would add from \$0.22 to \$0.45 per thousand to the value of all lumber cut. This applies particularly to mills cutting coniferous species to which the above alcohol yield and waste disposal figures apply.

From work going on at present, it seems that the yields from some of the hardwoods will not be as great as those obtained from the coniferous species.

In conclusion, the successful production of ethyl alcohol from sawdust seems to depend upon the proper design, equipment, and management of the plant, rather than its chemical or fermentological features. Large volumes of low grade materials must be handled

quickly and efficiently under unusual technical conditions. The perfection of the necessary acid-resisting pieces of apparatus, along with the experience of the plants that have been built, together with the utilization of material whose mere removal at present is an expense justifies a serious consideration of the future of this industry.

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The Flotation of Minerals*

BY ROBERT J. ANDERSON

During the past 5 years no subject has aroused more interest or received more attention among mill operators than flotation. One reason for this is, undoubtedly, the remarkable success of the process in Australia where that country has risen to the position of furnishing one-fifth of the world's supply of zinc. The plant of the Butte & Superior Copper Co., designed by James M. Hyde in 1912, was the first important large flotation plant in this country; other installations have been made since then with considerable frequency, particularly so in the last 2 years.

Without going into complete detail, it may be safely said that although flotation is a highly successful commercial process, it is more or less on an empirical basis. Upon scanning the literature, it is found that the flotation investigations have, in the main, dealt with a solution of the problems which accrue to practice; until recently no attempt was made to remove the difficulties in the way of the formulation of a consistent and harmonious theory. Of late this phase of the work has been receiving considerable attention, particularly by the United States Bureau of Mines at its Salt Lake City station, by the Mellon Institute at Pittsburgh, by the General Engineering Co. at Salt Lake City, by many of the mining schools, and private individuals almost *ad infinitum*. There is, at present, an enormous amount of laboratory work being carried on in flotation research, and probably the time is not far away when a generally acceptable explanation of flotation phenomena can be set forth. However, at this time, it seems as though the current technology is befogged with a superabundance of contradictory evidence; this confusion can only be dispelled as time proceeds and the knowledge of the subject becomes more complete.

Many phenomena are supposed to contribute to the flotation of minerals, whether in whole or in part is a mooted question. I shall only sketch roughly the present tendency of ideas and make no reference to the first early and crude notions which have little value other than historical interest. Many questions have arisen in connection with flotation concerning such matters as surface and interfacial tensions, adsorption, absorption or occlusion, colloids, emulsions, electrolytic and electro-static phenomena, etc. These phenomena are to be discussed in later paragraphs in order to ascertain what bearing they may have, if any, on froth flotation. No final solution of this very large problem is attempted in this paper, for in any discussion of flotation theory, at this time, one is confronted by so many obstacles that at best only a rather fragmentary presentation can be made. An attempt has been made in this writing to correlate the operative and fundamental principles and compare in a measure some of the theories so far advanced.

Discussion of Certain Factors

SURFACE AND INTERFACIAL TENSION

Surface tension has been rather well defined in arti-

*A paper to be presented at the Arizona meeting of the American Institute of Mining Engineers, September, 1916.

cles appearing in the *Journal of the American Chemical Society* during the years from 1908 to 1913. The theory of surface tension has been treated in particular by Laplace, Gaus, and more recently by Van der Waals, and by Willows and Hatschek.¹ As defined by Jones, "potential energy, present at the surface of liquids, produces a tension which is known as surface tension." The phenomena which are invariably indicative of surface tension are commonly observed: Drops of a liquid not exposed to an external force, *i.e.*, either suspended in another liquid of the same specific gravity or freely falling, assume a spherical shape, the sphere being that form of body with the smallest surface per given volume; further, if water be placed in an open vessel its surface film will be a measurable quantity, and its thickness will vary with a number of factors of which temperature is one. Its thickness is observed as ranging from 4×10^{-5} cm. to 4×10^{-3} cm., and its density, when referred to the main bulk of the water below, will approximate 2.14. Surface tension is not affected by the surface area. It is numerical in value and expressed in dynes per centimeter. It is a variable factor dependent on temperatures, increasing numerically with falling temperature, *e.g.*, water at 18 deg. C. has a surface tension of 73 dynes per centimeter, and at 0 deg. C. 75 dynes per centimeter. At the critical temperature of a liquid its surface tension becomes nil.

All liquids have a definite cohesion or tensile strength, which is ascribed to the well-known mutual attraction of their molecules. This then is comparable to a pressure existing within a liquid, which has been termed the "intrinsic" pressure. Naturally the value of the surface tension of solids is numerically a high one. The surface tension of a pure liquid against its vapor can be and is markedly affected by the addition of soluble contaminants. Some salts will raise the surface tension of water while others will lower it; the fact that the salts of weak acids will lower the surface tension of water is explained by the fact that free acid is liberated by hydrolysis. It is further known that all acids will lower the surface tension of water. The surface tension of water is decreased by the addition of oil, or better, oil will reduce the interfacial tension between the water-air phases. A phenomenon for which no explanation has been given is the one which shows that the addition of contaminants may either raise or lower the surface tension of water, but such addition, while it may decrease that tension greatly, can increase it only slightly. Any lowering of surface tension is more marked in a liquid which has a high surface tension, *e.g.*, water, than in liquids of low surface tension.

There can be, of course, no surface tension without adsorption, which produces, in the case of positive adsorption, an increased concentration resulting from a lowering of the surface tension by the contaminating and dissolved substance whatever it may be. The equation of Gibbs— $u = -c R t d\sigma/dc$ —gives the relationship between surface tension and the distribution of the solute between the bulk of the liquid and the film interface. Here the notation is:

- u = excess of substance in the surface layer,
- c = concentration in the main body of the liquid,
- R = the gas constant,
- t = absolute temperature,
- σ = surface tension.

This shows that when the surface tension is reduced by the addition of a contaminant, the quantity $d\sigma/dc$ is

negative and u is positive (from algebraic consideration). The surface film then contains more of the contaminant than the main body of the solution. If the surface film contains less of the contaminant than the main body of the solution it is a case of negative adsorption.

As given in the foregoing, the surface of a liquid against its vapor is in tension—surface tension; the surface of a liquid against another liquid, or a gas or solid, is also in a state of tension: this is termed interfacial tension. In the consideration of the bearing which surface and interfacial tensions have on froth flotation, this condition of affairs obtains in the flotation machine: Pulp consisting of ore of approximately 80-mesh, water in ratio of 3:1 of ore, and oil in disappearingly small amount, is being violently agitated. For the sake of a specific case, the air is being forced mechanically into the swirling pulp by beaters or stirrers. These phases then are present in flotation by the oil-froth process, *viz.*, solid-liquid (ore-water), solid-liquid (ore-oil), solid-gas (ore-air), liquid-liquid (water-oil), liquid-gas (water-air), and liquid-gas (oil-air). Thus six tensions are present, but if the oil is soluble in the water the tension number becomes three. It is known that pure water can not be made to maintain a persistent froth because its surface tension is too high. Acid, if present, will lower the surface tension of water, as will oil if it is soluble to any extent. Very many interesting and important, as well as speculative, consequences follow from a consideration of interfacial and surface tensions, and, in a later paragraph, we shall have occasion to return to the consideration of these complicated phenomena.

Certain metallic sulphides, *e.g.*, galena, have the power of floating on undisturbed water; they are not wetted and the curve of contact is convex. Some gangue minerals, *e.g.*, quartz, possess an adhesive force of attraction for water which exceeds the intrinsic pressure of the water; they are therefore wetted and sink to the bottom, being drawn through the surface film. Such properties of the minerals are affected by the presence of oil, acid, and other reagents. Oil has a greater adhesive attraction for sulphide minerals than for gangue minerals; and the addition of acid and oil (if it is soluble) acts as a contaminant which will lower the surface tension of the water and aid in the production of a persistent froth. Let us now look into the question of adsorption and see what part it plays in flotation, since it is so requisite to the production of a variable surface tension.

ADSORPTION.

Generally speaking, adsorption deals with the unequal distribution of substances at the interface between dissimilar phases such as, solid-solid, solid-liquid, solid-gas, liquid-liquid, liquid-gas, and gas-gas. It is purely a physical effect. Commonly, adsorption² is construed to be the result of the condensation of a disperse phase upon the interfacial boundary solid-liquid. Returning for a moment to the Gibbs equation mentioned above, adsorption may occur if the interfacial tension solid-liquid is reduced—this being positive adsorption. If, however, such an interfacial tension is raised in value it is a case of negative adsorption as the solute or disperse phase will be rejected from the surface. Any condensation, strictly stated, of a solute or disperse phase in the interfacial boundary separating liquid-liquid or liquid-vapor is held to be a special case of adsorption. However, in the general sense, the phenomenon is looked upon as being the

¹Willows and Hatschek: *Surface Tension and Surface Energy*, 1917.

²Jones: *Elements of Physical Chemistry*, 1907.

³Reynolds: *Transactions of the American Chemical Society*, Vol. XIX, No. 1, p. 1 (March, 1915).

result of condensation of a disperse phase in the interface of two immiscible phases. Adsorption is shown very strikingly by colloid gels—the product obtained by the coagulation of sols—and certain cases of selective adsorption are very remarkable. Adsorption will naturally vary with the surface exposed. In Miss Benson's experiments with amyl alcohol in aqueous solution, amyl alcohol reduced the surface tension of the water, and it was found by producing a voluminous froth that the alcoholic concentration in the froth exceeded that in the bulk of the aqueous solution by about 5 per cent. A froth has a very large surface, and it would be expected that the adsorption would be greater. Such experiments prove the value, qualitatively, of the Gibbs rule.

Recent work shows that all solids do condense certain amounts of gases on their surfaces and retain them there with very great tenacity. Liquids in like manner adsorb gases. Further, liquids and solids exhibit marked selective adsorption of gases. Although this selective adsorption obtains, no evidential proof has been submitted which says that the amount of gas adsorbed by one substance is largely different than the amount adsorbed by another substance. An electric charge on an adsorbed substance probably would considerably influence the amount adsorbed. The adsorption of air plays an important rôle in flotation, for as Breuer points out, the adsorbed air film is enormously responsible in preventing the coalescence of solid particles.

A comprehensive study of the adhesion of small particles of solid to the dineric interface (surface separating two liquid phases) has been made by Hofmann,⁴ based on the theory of Des Coudres.⁵ From the standpoint of flotation this may be given as follows: If a solid particle, *e.g.*, quartz, is wetted much more strongly by water than by another liquid, *e.g.*, oil, the water will displace the oil, and a film of water will form about the quartz particle according to the relative forces of adhesion. Then the quartz particles will remain in the water phase if the water has a specific gravity greater than the oil, regardless of their size; but if now the oil has a greater specific gravity than the water, then the quartz particles will remain in the water phase until the size of the particles is such that the force of gravity will remove them from the water. Conversely, if a solid particle, *e.g.*, galena, is wetted more strongly by oil than by water, the oil will form a surface film about the particle and hence prohibit the particle from being wetted by water, *i.e.*, from entering the water phase. Then the galena will only enter the water phase when the water is more dense than the oil, and, further, when the galena particles are of such a size that the force of gravity overcomes the adhesion of the oil film to the oil.

Returning to purely theoretical considerations, Hofmann draws certain conclusions at this juncture which deal with the supposition that solid particles will then remain in the surface separating two immiscible liquids, if those particles are wet partially by each liquid. I quote Bancroft at length on this matter:⁶ "The solid particles tend to go into the water phase if they adsorb water to the practical exclusion of the other liquid; they tend to go into the other liquid phase if they tend to adsorb the other liquid to the practical exclusion of the water; while the particles tend to go into the dineric interface in case the adsorption of the two liquids is sufficiently intense to increase the miscibility of the two liquids very consider-

ably at the surface existing between solid and liquid."

Any simultaneous adsorption of two immiscible liquids by a solid would probably tend to result in the formation of a homogeneous liquid phase at the surface of the solid.

In regard to the effect of contaminants or other impurities in contact with two immiscible liquids, this condition obtains: If the contaminant is soluble in one liquid but not in the other, and also lowers the interfacial tension of the two, the equation set forth by Gibbs exacts the requirement that the contaminant should obtain in the interface. Examples of this prove the validity of the law.

The terms adsorption and absorption have been used interchangeably in some writings, thus contributing to the already existing confusion of ideas.

ABSORPTION OR OCCLUSION.

There are three ways by which gases can be held with reference to solids: *viz.*, (1) By surface adsorption; (2) in solid solution; and, (3) by occlusion. The term "occlusion" has been applied indiscriminately to any of these above methods by which gases are held by solids. Strictly speaking, by occluded gas is meant gas which is adsorbed and held in finely divided pores or openings which may be of microscopic size.

A recent theory⁷ holds that occlusion plays the operative rôle in the flotation of minerals by all processes. I am unable to reconcile myself to this explanation for a number of reasons. Marked instances of occlusion at normal temperature are known only in certain amorphous substances like charcoal. Many metals, of course, both in the liquid and solid states, have the power of occluding gases, often in marked degree. There may be and undoubtedly are fine pores in the floatable minerals, which may in a sense be considered as an assemblage of capillary tubes; these can and do occlude gas. Yet occlusion is marked only in amorphous substances and in certain metals as just stated. It is definitely known that occluded gases are retained with very great tenacity by the substances occluding them and therefore expelled only with difficulty. It seems anomalous then to hold that the occluded gas can depart from the mineral occluding it with sufficient speed to aid the air bubbles in the liquid in the process of flotation.

I believe rather firmly that occlusion is not a cogent factor in flotation by any process, and that a more consistent theory may be formulated without postulating these conjectures regarding occlusion.

COLLOIDS.

Colloids, in the original definition of the term by Thomas Graham, are not a definite class of substances; rather a large number of different substances may be made to assume the colloidal state if proper precautions are taken. All of which reveals the striking fact that this colloidal condition is a *state* and not a *form* of matter. The ultra-microscope of R. Zsigmondy and H. Siedentopf has increased the knowledge of colloids to a great extent. A rather general statement may be made regarding colloids and that is, that they do not show osmotic pressure in any appreciable amount. Colloidal solutions—sols—are regarded as systems of two phases, in which the dissolved substance is the disperse phase and the solvent the continuous phase.

Since in flotation the ore is often as small in size as certain of the colloids, the flotation pulp, (ore, water, etc.) can be looked upon as a coarse suspension, and the laws of colloids apply here with equal force as in

⁴*Zeit. Phys. Chem.*, Vol. 1, 88, 111, p. 385, 1913.

⁵*Arch. Naturgesch.*, Vol. VII, p. 322, 1898.

⁶Bancroft, *Journal Physical Chemistry*, Vol. XIX, No. 4, p. 287 (April, 1915).

⁷Durell: *Mining and Scientific Press*, Vol. CXI, No. 12, p. 428 (Sept. 18, 1915), and Durell: *Metallurgical and Chemical Engineering*, Vol. XIV, No. 5, p. 251 (March 1, 1916).

the realm of colloidal chemistry. So-called suspensions are systems consisting of solid particles of microscopic size distributed through a liquid. As mentioned by Ralston,⁸ Reinders has treated at length the particular case of a solid phase maintained in contact with two liquid phases, i.e., two immiscible liquids. His work is based on the different interfacial tensions existing, and his experiments and those of Hofmann, as mentioned in an earlier paragraph, have considerable bearing on the flotation problem.

EMULSIONS.

Emulsions are fairly coarse dispersions of one liquid in another with which it is immiscible. The simplest and commonest emulsions are the oil-water emulsions, i.e., the pure oil-water emulsions, containing no emulsifying agent such as soap, proteids, etc. In such systems the oil globules can be coagulated by electrolytes, show the Brownian movement strikingly, and can even be retained by some filtering media. Any process of emulsification is dependent on a surface tension lowering, or, to be more precise, on a lowering of the interfacial tension between the two phases. According to Briggs and Schmidt,⁹ the two essential requirements of an emulsifying agent are these: (1) The property of condensing by adsorption in the dineric interface; and (2), the ability to form under these circumstances a strong coherent film. Temperature is a cogent factor in emulsification, for its effect is to reduce the interfacial tension between phases and also to lower the viscosity of the phases. In the production of emulsions, a considerable amount of surface energy is produced because of the relatively large surface area of the disperse phase; an emulsion is the more speedily effected if such surface energy be reduced by the use of a liquid having a low surface tension as the continuous phase. Some emulsions, under certain conditions, display a great increase in viscosity over that of either of the immiscible phases, e.g., the emulsions of the Pickering order—up to 99 per cent of oil in 1 per cent of soap solution—can be cut into cubes. Any emulsion produced with soap solution is at once rendered nil by the addition of acid as the latter will decompose the soap.

If solid particles are suspended in a liquid, they tend to increase the viscosity of that liquid only gradually depending on the amount of solid particles present. Experiments have shown that whenever a substance which is in suspension is wetted by two immiscible liquids simultaneously, it will go into the dineric interface in the manner already referred to, and will therefore tend to produce an emulsion. If, however, the suspended particles can not coalesce due to adsorbed oil film or for other reasons and thus effect the production of a coherent film, the emulsion will not be stable. Very little data are available on the production of emulsions by the oils used in flotation work, or on the matter of interfacial tensions between such oils and water. However, we are no doubt dealing with emulsified or partially emulsified pulp in some of the flotation processes, e.g., the oil-froth process at least.

ELECTROLYTIC AND ELECTROSTATIC PHENOMENA.

Any substance which is placed in contact with water or many other liquids will assume an electric charge, the origin of which is, as yet, not set forth. Most substances when in contact with water become negatively charged, but these charges can be differed at will or reversed by the addition of the proper electrolyte in re-

quisite amount. These electric charges are by no means confined to submicroscopic particles but are found also on the particles of a coarse suspension. Gangue minerals, e.g., quartz, when suspended in water, are negatively charged, and sulphide minerals, e.g., pyrite, are positively charged under like conditions. Oil drops are negatively charged, as are air bubbles under certain conditions which will be given subsequently. These charges are very minute when referred to the mass of the particle. Substantial evidence is at hand which goes to show that floatable minerals have the positive sign of electricity when suspended in water or can be made to assume that sign by the addition of proper electrolytes in sufficient amount. As Callow¹⁰ observes, there is a parallelism between electrostatic characteristics and the flotation properties of ores. Many of the electrostatic principles have either been carried too far or misapplied as recent work shows.

Experiments in the realm of colloid chemistry indicate that the contact films are charged and that such charges markedly affect the dispersion or coherence of the particles in suspension. Naturally, oppositely charged contact films will coalesce while similarly charged contact films will repel each other, if the charges are sufficient in amount to overcome the force of cohesiveness; in the latter, dispersion is the result. The oil and air contact films having negative charges would tend to attract the sulphide particles, but further than this possibility electrostatics probably plays little part in flotation for the reasons given in the following paragraph.

As referred to above, it is pretty generally admitted that only minerals which are good conductors are suitable to flotation. Now then, as the electrical theory contends, electrified bubbles must be supplied to float the conducting minerals which are attracted, leaving behind the minerals which are not. The bubbles in flotation are simply air spaces contained by a mantle of oil or water, and there is, therefore, nothing within to bear the charge. In case it could carry a charge, which would only be possible by the presence of contained ionized gases or water vapor, the charge would be speedily dissipated by contact with the interfacial boundary. Then in order for a bubble to carry a charge it must be protected by a dielectric film. Further, electrostatics plays probably little part in holding the sulphide particles and the gas bubbles together as neither the bubble nor the particle can have a charge of sufficient magnitude when referred to the size. The electrical theory has been strongly championed by at least one writer¹¹ and has been tolerated by some others. A recent article¹² indicates that the principles of electrostatics have been considerably misapplied. It is my belief that electrostatics may be a small contributing factor in flotation in a manner not as yet understood because of a lack of data concerning charges at the interfacial boundary between immiscible phases, e.g., where the colloidal state is introduced in oil-water emulsions. Apparently, as far as any data at hand are concerned, they all serve to condemn any attachment of great importance to the electrical theory.

The Character and Formation of Flotation Froth

Bearing in mind the phenomena discussed above, let us turn to the flotation of minerals by means of the froth process and look into the character and formation of froth. A froth has been defined as a multiplica-

⁸ M. Callow, *Industrial Minerals*, No. 108, p. 142 (London, 1915).

⁹ Briggs, *The Electrical Theory of Flotation*, *Minerals and Smelting*, (1915), Vol. CXI, No. 23, p. 523.

¹⁰ Bains, *The Electrical Theory of Flotation*, II, *ibid.*, Vol. CXI, No. 24, p. 582 (May 11, 1915).

¹¹ Fahrenwald, *The Electrostatics of Flotation*, *ibid.*, Vol. CXI, No. 11, p. 37 (March 11, 1916).

⁸ Ralston: *Mining and Scientific Press*, Vol. CXI, No. 17, p. 624 (Oct. 23, 1915).

⁹ Briggs and Schmidt: *Journal of Physical Chemistry*, Vol. XIX, No. 6, p. 479 (June, 1915).

ity of bubbles; this seems to be wanting in some respects but will be requisite and sufficient for this purpose. The froth of flotation is formed by the action of air or gas in water containing impurities or contaminants, for pure water will not maintain a froth.

FROTH AND BUBBLES.

The idea has been abandoned of late, by most people, that a low surface tension is the essential requirement for froth formation. As mentioned by Coghill in a recent writing, the contamination of the liquid with an impurity which will cause a variable surface tension is the real requirement. A bubble of air is spherical in shape and this shape can only be maintained if the external pressure exceeds the internal pressure. Since a bubble does not expand *per se*, large bubbles can only be accounted for by heat, coalescence or electrification. Viscosity is an important factor in froth persistence as it increases the tenacity of the liquid film and thus prevents ready rupture. The rupture or bursting of bubbles is accounted for by these reasons:

1. Concussion upon a surface film which is deficient in the requisite viscosity and variable surface-tension.

2. Relief of pressure—here the gas of the bubble in expanding exerts a pressure which exceeds that of the liquid film.

3. Adhesive force of the entrained gas for the atmospheric air.

4. Evaporation of the liquid film.

Flotation bubbles will burst then for any one or a combination of all these reasons.

Solutions in which the continuous phase is a solution of soap, various products from the saponification of albumens, etc., will froth voluminously even in a very diluted condition; frothing never occurs in pure liquids and is a definite proof that the solute or disperse phase lowers the surface tension of the solvent. A froth, which shows adsorption at the interfacial boundary of solution and gas, depends for its persistence on the production of a viscous film at that boundary; these viscous films are the direct result of surface adsorption of the disperse phase, *i.e.*, dissolved contaminants, the amount of which is small—disappearingly so. The work of Hall and of Miss Benson shows that in a foaming liquid the foam is richer in dissolved contaminant than is the bulk of the liquid. Froth formation in the Callow cell is the result of the injection of air into the pulp (already emulsified); the froth continues to obtain as long as there is sufficient air injected into pulp of the proper consistency. The froth in the Callow cell is governed in nature by the kind of oil used and by the amount of air. A pneumatic froth is unstable or ephemeral, *i.e.*, it dies rapidly when removed from the influence of the injected air. The mechanical froth, on the other hand, is thick and persistent, and must be broken up in dewatering the concentrates.

OILS

Oils have a well-marked selective action for metallic sulphides, tellurides and some other minerals. The fact that both the oil and the air or other gas have a selective adhesion for sulphides prevents them from being wetted by water. Conversely, the quartz and other minerals exhibit just the opposite characteristics. The gangue minerals, generally, do not exhibit adhesion for either gas or oil, and hence they are readily wetted by water. Gases have a well-defined adhesiveness for oils; hence the air or gas adheres strongly to the oil film. The stability of a froth depends, in the main, on the kind of oil used, *e.g.*, pine oil makes a weak brittle froth, and creosote makes a stable elastic froth. The

work of Devaux¹ on oil films explains how so small an amount of oil as is used in the various flotation processes can be so efficacious. From a consideration of the immiscible oil-water interface, if any oil will film the internal surface of a gas bubble the sulphide mineral particles would be contained in the oil-water interface no matter what the nature of the gas contained by the water film. The sulphide, if it enters the oil phase, would then present an oiled surface to the water phase. There are three conditions then: (1) The mineral enters the oil phase completely; or (2) the mineral enters the water phase completely; or (3) the mineral enters the oil-water interface.

Some experiments made to determine the nature of the frothing power, selective and collective action of different oils show some interesting results. I made some tests on a zinciferous slime from the Joplin area with different oils and the results obtained indicate that a definite mixture of oils will effect better recoveries than any one oil alone. The best combination consisted of pine oil as a frother, plus wood creosote as a frother and selector, plus refined tar oil as a froth stiffener. The complete results of these experiments will be given in a later paper.

In general, pine oil makes a brittle froth which immediately dies; creosotes make a more elastic froth, the bubbles of which may expand to 3 in. in diameter or more before rupture. Coal-tar products are rather poor frothing agents and if used must be aided by either creosote or pine oil to produce a good froth. Oils of a lubricating nature seem to be of little value as flotation oils, while such light oils as gasoline and naphtha are of value only for thinning the heavy coal and wood tars.

AIR AND GAS

At this time there are three ways by which a gas may be forced into a solution mechanically, *viz.*:

1. By beating it into the solution by means of beaters or paddles—as in the Minerals Separation and similarly mechanically agitated machines.

2. By pneumatic means—as in the Callow cell where the air is divided by the porous blanket bottom into minute sprays.

3. By so-called liquid jets—as in a process recently patented in which the air is introduced as a surface film surrounding a liquid jet by surface tension.

Conversely, there are three methods by which dissolved gas may be expelled from a liquid, *viz.*:

1. When the liquid is supersaturated, the excess gas is expelled.

2. By heating the liquid, when some of the gas is expelled due to an increase in its volume.

3. By pressure reduction, as in the Elmore vacuum process, where, according to the law of Henry, "the amount of gas dissolved by a liquid is proportional to the pressure to which the gas is subjected."

An air or gas bubble on being introduced into a liquid is at once surrounded by a film of the liquid. Such a bubble will rise to the surface (carrying the metallic sulphides by reason of the forces already mentioned) on account of gravitation, by which is understood that the adherence of the air to the liquid is less than the force of gravity.

Résumé

From a consideration of the foregoing, it is believed that the theory based on the different interfacial tensions involved is the dominating one as well as the more consistent at this time. Probably flotation is due to a combination of phenomena which are rather high

¹Devaux, Oil Films on Water and on Mercury. Smithsonian Report of 1913, p. 261.

²Gilman, Elements of Physical Chemistry, p. 177, 1907.

in the scale of complexity. The theory based solely on occlusion goes "by the board" as it has been shown that the contributing effect of this phenomenon has been interpreted rather laxly.¹ The phenomenon of electrostatics may be a small contributing factor but recent work indicates that the principles have been misapplied. An explanation more in consonance with fact can be given in terms of the interfacial tensions involved, without postulating either occlusion or electrostatics, as mentioned above.

The main and essential requirements for froth flotation are: (1) The production of a persistent froth by any means; (2) the attachment of the bubbles of air to the sulphides or other material to be floated; and (3) the maintaining of a selective action of the froth bubbles for the sulphides or other material to be floated.

Why this is accomplished is outlined in the above, particularly under the subhead, "Adsorption." Probably, before any generally satisfactory estimate of the many complex factors, which are supposed to be involved, can be secured, a more thorough investigation of all of them will have to be made than has thus far been attempted. However, in this line of inquiry there has been a steady progression of thought and a remarkable increase in knowledge in the past few years; and the art of flotation will continue to improve and develop as the more complete knowledge of the different factors involved increases and allows the exercise of a better control of them.

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Testing the Durability of Pipe Under Corrosion*

BY F. N. SPELLER

All will agree that a service test, or at least a test under service conditions, is the only reliable method for determining the relative durability of iron and steel products. However, to be of any value it must be possible to carry such a test to conclusion in a reasonable time. The so-called "acid test" quickly attracted attention, but as this proved to be misleading the effect has been to discount any attempt to accelerate corrosion. Nevertheless, there are certain conditions commonly found in service where pipe is subject to aerated water at a temperature of 140 to 180° F. under pressure, where corrosion is very severe. The method of testing here referred to works under such conditions, which are more or less common to all water and steam-pipe service.

The main factors controlling corrosion in pipe are:

1. The amount of free oxygen in solution in the water.

2. The volume of flow, which is an important factor, mainly on account of the greater amount of oxygen available; and

3. Temperature. Corrosion increases with the temperature, reaching a maximum somewhere between 160 and 180° F.

These conditions are reproduced in the apparatus shown in Fig. 1. This consists of a tank reservoir open at the top, which may be filled with a supply of any kind of water selected for the test. This water is main-

tained at any desired temperature by means of a small gas heater *B* fitted with a thermostat, or a steam coil may be inserted if more convenient. An ejector is provided at *C* and operated by air under three or four pounds pressure. The air should first be passed through a mass of excelsior or similar material to re-

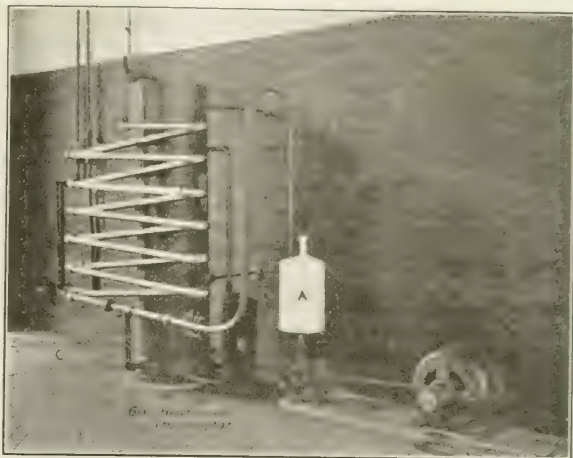


FIG. 1—APPARATUS FOR CORROSION TESTING, USING AERATED HOT WATER

move oil. The heated water is thus aerated, forced up through the coil of pipe and discharged continuously into the top of the tank. The coil consists of alternate lengths of the materials under test. A glass tube may be inserted in the coil if it is desired to observe the flow. By keeping up a continuous flow in this way at a temperature of 160 to 180° F. the relative tendency of pipe to corrode may be determined in three to four months. The amount of corrosion found in that time with this apparatus will be found equal to about two years under the same conditions in actual service.

The acceleration of corrosion in this apparatus is principally due to the continuous flow and the greater amount of oxygen and carbonic acid which is thereby brought into contact with the interior surface of the pipe. The details of this machine may be altered according to local conditions. If the water is not fresh and almost pure, the supply should be renewed from time to time.

The amount of corrosion in both wrought-iron and steel hot-water supply pipe, as measured by the depth of pitting, will frequently amount to about 0.1 in. in two years. We have found with this apparatus nearly this amount of corrosion in pipe of this kind in three months, with the water circulating at the rate of one to two gallons per minute. The relative depth of pitting is apparently the same in each case.

The writer has used this scheme for two years in research work on the improvement of pipe and pipe coatings, with much saving of time compared with similar tests on pipe in actual use.

Increased Production of Bauxite.—The production of bauxite in 1915 showed an increase of 34 per cent over the 1914 output, due to the great demand for it in the aluminum industry. The production according to the Geological Survey was 297,041 long tons. Only about 1 per cent of the total consumption was imported.

*A paper read at the Atlantic City meeting, 1916, of the American Society for Testing Materials.
†Baldston, "Why Do Minerals Float?" *Mining and Scientific Press*, Vol. CXI, No. 17, p. 623 (Oct. 23, 1915).

The Theory of the Corrosion of Steel*

BY LESLIE AITCHISON

The problem of the corrosion of iron has been the subject of a great deal of attention during the past twenty years or so. By means of a very large number of experiments, conducted by various workers, amongst whom may be mentioned Sir William Tilden, Messrs. Walker, Whitney, Moody, and Friend, a number of facts have been accumulated, and two theories have been put forward to account for the actual corrosion of iron. In practically all these cases, the material employed has been pure, or nearly pure iron (*e.g.* the iron foil of Kahlbaum), and in most cases the interest has centered round the attack upon this by pure water (that is, frequently distilled water). At the present time the question is an open one, as to the actual details of the corrosion under these conditions, and the present author does not propose to enter upon that particular field.

Most of the workers have left the theory of the corrosion of steel, which is a material of much greater complexity of structure than iron, rather well alone. This particular problem may be attacked, however, quite apart from the one stated above, and although it may be rather premature to define a concise theory of the corrosion of steels, yet the author feels that certain points might be discussed with advantage, as some fair amount of experimental evidence has accumulated. Acting upon this, the author wishes to put forward, with all modesty, the points which follow, in the hope that, even if they are not acceptable to all those who have thought out this problem, they may give rise to the expression of some other opinions, and so help towards the fixing of some precise idea upon this most interesting subject.

The complex structure of steels, composed as they are almost invariably of carbides imbedded in a matrix of some carbon-free material, renders it almost certain that the action going on in a steel during its corrosion is a galvanic one. This conclusion is not seriously at variance with either of the two theories mentioned above as to the essential nature of corrosion. The large number of galvanic couples present in an ordinary sample of steel can be well imagined, and these couples will consist of the carbide on the one hand, and the ferrite or solid solution on the other. This postulates at once that one of the two constituents will be anodic in its action, and the other cathodic. The anodic one will be attacked by the solution—that is, the material composing the anode will pass from the atomic to the ionic condition.

The other material, acting as the cathode, will remain in the atomic (or molecular) condition, and hence will appear to be unattacked. The intensity of the galvanic action between the two constituents will depend, other things being equal, upon the potential difference between the two constituents with respect to the corrosive liquid which is in contact with the steel.

The carbides in all steels, although of varying chemical composition, will be likely to be possessed of very similar electrical properties, and hence it appears reasonable to assume that the electrolytic solution pressure of all the carbides will be the same, or nearly so. On the other hand, the solid solution, which may range from practically pure iron to an alloy containing many per cents of a second element, will be a material of very varying electrical properties. As a result the electrolytic solution pressure of this constituent will change very considerably from steel to steel, and will in consequence produce a considerable variation in the potential difference existing between the constituents of the steel. As a result the corrosion of the steel should vary a great deal with changes of composition.

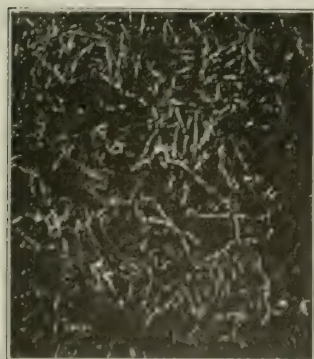
All investigators have agreed up to the present in regarding the carbides as being electro-negative (that is, as having positive electro-affinity, or a greater tendency to exist in the molecular than the ionic form). Hence their action should be cathodic, and they should not be attacked by the corrosive liquids. That this is so may be seen by microscopic examination. Two typical structures after corrosion are shown in micrographs Nos. 1 and 3 (Plate 1), the massive carbide being quite obvious in the two cases. The first is a pure carbon steel containing 1.25 per cent of carbon, and the second is a steel containing 0.73 per cent of carbon and 21.5 per cent of tungsten.

A similar result is obtained by an investigation of the attack of dilute acid upon various steels. By an analysis of the material which goes into solution, and a comparison of this with the compositions of the carbides separated by other methods, it will be found that the carbides are not attacked, and are left in their original form.¹

As a result of this the carbides in steel may be regarded as acting in two different directions. First of all, they act as resisters of corrosion. Since they are not attacked by the corrosive liquids, there should be a

**U.F.* author, *Transactions of the Chemical Society*, 1916, Vol. CIX, p. 288, and Arnold and Read, *Journal of the Iron and Steel Institute*, 1910, No. 1, p. 169; 1911, No. 1, p. 249; 1912, No. 1, p. 215; *Journal of the Institution of Mechanical Engineers*, 1914, No. 1, p. 233; 1915, No. 1, p. 247.

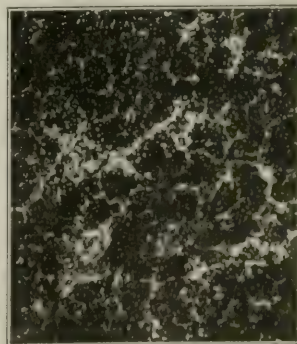
*A paper read at the annual meeting, 1916, of the (British) Iron and Steel Institute.



MICROPHOTOGRAPH 1—1.25 CARBON STEEL AFTER CORROSION



PHOTOGRAPH 3—PHOTO OF MELTED BAR IRON, CONTAINING 0.07 C, 0.018 SI, 0.09 MN, 0.031 S, 0.010 P. CORRODED IN SODIUM CHLORIDE



MICROPHOTOGRAPH 2—STEEL CONTAINING 0.73 PER CENT CARBON AND 21.5 PER CENT TUNGSTEN. AFTER CORROSION

smaller loss in a steel which is composed largely of carbide than in one which contains only a moderate amount of that constituent. This may be, and probably would be, true, were it not for the other action of the carbides. This is connected with their cathodic action. The intensity of the galvanic action will be to some extent proportional to the area of contact between the two constituents. The more finely divided the carbides, the greater will be the area of the surface of contact; and also the larger the quantity of carbide the greater the available number of surfaces of action.

That this is true may be seen from the figures of Table I. The first pair of results demonstrate the second action, of increasing the carbide, whilst the remaining ones show the first action—that is, of increasing the fineness or the state of division of the carbide. This latter is the normal result of the addition of small proportions of a third element (that is, one besides iron and carbon) to steel.

These three pieces of evidence—the microscopic, the analytical by sulphuric acid, and the effect upon the corrosion—may be taken as conclusive in proving that the carbides act throughout as cathodes. The rest of the material then becomes the anode in the various galvanic couples present in the material. As stated above, this residue of the steel is practically always solid solution. In the case of ferrite, the solution is extremely dilute, sufficiently so for the ferrite, to be termed pure iron, while in other cases there may be as much as 12 or 15 per cent of a second element.

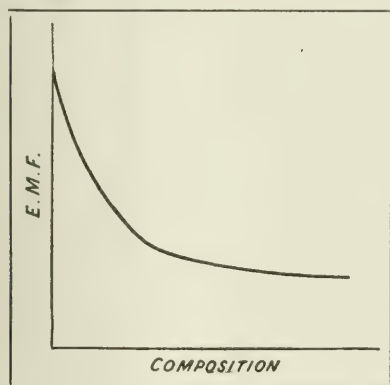


FIG. 1.—GENERAL TYPE OF CURVE GIVEN BY A SOLID SOLUTION

Considering the ferrite alone, two cases arise. First of all, there is the common one, in which the ferrite is present in contact with some carbide and acts as the anode in a galvanic couple.

This case is perfectly simple, the action coming about in consequence of the solution pressure of the iron (the

electro-affinity of iron—i.e., the potential of the metal against a normal ionic solution of its own ions—is—0.063 volt, iron being one of the metals which have a greater tendency to exist in the ionic than in the atomic condition). The negative electro-affinity in the case of the iron, and the positive (assumed) in the case of the carbide, produce all the essentials for galvanic action.

The other case is that of a relatively pure metal—e.g., bar iron—in which practically the whole of the material is composed of crystals of ferrite. As is well known, this material does corrode, and fairly rapidly too. The corrosion on the part of the ferrite in this case has been explained by the galvanic theory, on the assumption that the various grains of the metal have somewhat different solution pressures in consequence of the variation in the orientation of the different crystals. Also the presence of different degrees of mechanical strain in the various crystals is invoked as an explanation of this.

It appears possible, however, that neither of these explanations is necessary, in view of the more accurate knowledge that we possess of the structure of pure metals. Many workers have demonstrated the existence of a material in between the crystals of a metal, which has properties quite different from those of the adjacent crystals. The theories that have been advanced as to the nature of this material need not concern the present discussion, since they all have a point of agreement in that they admit the material to be amorphous.²

The orientation of the adjacent grains being different, there exists in this intergranular volume a material having the orientation of neither. It has been shown by various workers that the properties of an amorphous metal are very different from those of the same metal in the crystalline condition. Amongst other things, it has been made very probably true, that an amorphous substance is possessed of a very different solution pressure from that of the crystalline substance. It has been definitely established frequently, that a worked material has a much greater solution pressure than an unworked one;³ and as the amorphous layer in between the crystals has a relatively close similarity to a worked material, it is not unreasonable to imagine that the solution pressure of this layer is greater than that of the adjacent crystals. Lüttke⁴ has shown that mirror silver (which is in the strained or worked condition) will show a potential difference of as much as 0.1 volt when coupled with ordinary silver in dilute acids, and Andrews⁵ has found that the strained and unstrained portions of a wrought iron shaft gave a difference of potential of 0.016 volt, in a solution of sodium chloride.

Whichever phase has the greater solution pressure, the result of the existence of a potential difference will be galvanic action, and hence corrosion. This galvanic action would be between the intercrystalline material on the one hand, and the crystals of ferrite on the other. Either of these may be the positive member of the couple, and lose weight. In a perfectly annealed specimen, in which there is but little mechanical strain, it is probable that the action will be confined to that between the ferrite and the cement. If there is any potential difference, however, between the crystal grains due to any cause, then this will add to the effect, and the total corrosion will be the sum of the two actions. It is just possible, though improbable, that the solution pressure of the cement may lie midway between that of the more positive and the more negative grains of ferrite, in

TABLE I

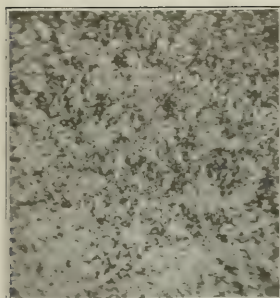
Carbon, per Cent	Other Element, per Cent	LOSS OF WEIGHT IN		
		3 per Cent Sodium Chloride Solution	Tap-Water	10 per Cent Sulphuric Acid
0.50		0.992	0.88	4.57
0.89		1.196	0.92	10.82
0.74	W 2.36	1.54	0.97	8.42
0.73	Co 2.68	1.55	0.94	5.12
0.63	V 0.71	1.73	0.90	8.05

² P. Rosenhan and Ewen, *Treatise on the Properties of Metals*, 1912, No. 2, p. 119. 1913, No. 2, p. 119. and Humphrey, *Iron and Steel Institute*, Carnegie Scholarship Memoirs, 1914, Vol. V, p. 88.

³ E. Fawcett, *Journal of the Society of Chemical Industry*, 1906, Vol. XXV, p. 113.

⁴ *Annals of Physical Chemistry*, (2) 50, p. 678.

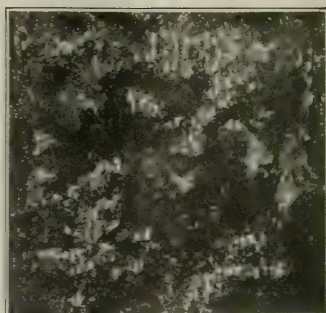
⁵ *Proceedings of the Institution of Civil Engineers*, 1894, Vol. CXVIII, p. 10.



MICROPHOTOGRAPH 4—NON CORROSIVE CHROMIUM STEEL



MICROPHOTOGRAPH 5—TWIN CRYSTAL STRUCTURE AS REVEALED BY CORROSION



MICROPHOTOGRAPH 6—0.89 PER CENT CARBON STEEL, AFTER CORROSION

which instance the action of the cement will be anodic in one case and cathodic in another.

Taking the simplest case, namely, the one in which the ferrite is roughly at the same potential throughout, and the intergranular cement at another, then there should be an action developed at the junction of the two substances. The action may not be confined to this face of contact, but will proceed at a maximum rate on that plane. The result should then be that the lines of junction of the crystal show this more intense action, and the evidence should take the form of a relatively deep pit sunk round the crystals. That this evidence is to hand may be seen from the photograph No. 3 (Plate 1), which shows a melted bar iron, having the following composition: carbon 0.07 per cent; silicon 0.018 per cent; manganese 0.09 per cent; sulphur 0.031 per cent; phosphorus 0.010 per cent, after undergoing corrosion in sodium chloride. This theory would account more or less completely for the corrosion of a pure metal.

Passing on to the question of solid solutions, several very interesting points arise at once. Assuming that the action in the case of steel containing carbide and solid solution is similar to that in those consisting of carbide and ferrite, that is, galvanic with the carbide as cathode, it should be evident that the controlling factor in this instance will be the solution pressure of the solid solution, and this will vary with its composition.

The solid solution found in steels have very various compositions, and these have been determined indirectly by Arnold and Read,⁴ and directly by the author.⁵

The results obtained are of interest, and show that in the case of molybdenum, vanadium and tungsten, these elements do not enter into the solid solution until a relatively high percentage of the element is present. At first the tungsten, vanadium and molybdenum are associated entirely with the carbon, and form a part of the carbide. In the case of vanadium, the "saturation" percentage of the carbide is about 5.4, for tungsten about 11.7, and for molybdenum about 19.0. Below these percentages these elements are not found in the solid solution. As a result, the concentration of the solid solution for these elements, even after they do find their way into this constituent, is never very high.

In the case of chromium, this element appears in both carbide and solid solution from the start, and hence the solid solution is much more concentrated in chromium at lower percentages than for any of the previous elements. Nickel behaves in a way just the opposite of vanadium and molybdenum. In the case of that element the carbide is found to be free from nickel until the steel contains more than 8 per cent of nickel. Prior to this the

solid solution receives all the nickel, and in consequence is more concentrated at lower percentages than that found in any of the other alloys.

Up to the present our knowledge of the actual electromotive force curves of these alloys of iron with vanadium, tungsten, molybdenum, etc., is not very great, but the general type of curve provided by a solid solution is well known. In general, it is a logarithmic curve of the form indicated in Fig. 1.

It will be granted that in all the alloys designed to resist corrosion, it will be necessary for the solution pressure (as reflected in the electromotive force) of the solid solution to undergo some considerable change from that of iron, in order that the difference of potential between the solid solution and the carbides shall be sufficiently small as to minimize corrosive action. From the electromotive-force curve it should be evident that there is no sudden change of solution pressure in the alloys forming the solid solution, and that in consequence it will be necessary for the solid solution to become relatively concentrated in the alloying element before the required change of solution pressure can be accomplished.

The corollary to this is surely that there is only likely to be any diminution of corrosion if the new element finds its way into the solid solution early in the series, and also becomes present in reasonable proportions. For any element that goes into solid solution in the steel a small percentage is not likely to be of the slightest value in resisting corrosion. That this view is true may be seen from the following cases.

The author has examined the influence of composition upon the corrosion of steels by determining the loss of weight experienced in various liquids by steels containing carbon only, and carbon with varying percentages of tungsten, vanadium, chromium, cobalt, molybdenum, copper, nickel and manganese.⁶ The results of these experiments show that very few steels containing a third element have any advantage to offer over those containing merely iron and carbon.

The most conspicuous exceptions are the steels containing a high percentage of chromium. The corrosion curve for these alloys is shown in Fig. 2, and it will be seen that it is only in those alloys where there is a good deal of chromium that any improvement occurs. As was stated above, in these steels the chromium is found in both the carbide and the solid solution; from the smallest percentages and the composition of the solid solutions for the steels whose corrosion was shown in Fig. 2 are given in Fig. 3. There it will be seen that the solid solution does contain a reasonably high per-

⁴ *Transactions of the Faraday Society*, 1915, Vol. CVII, p. 1531.
⁵ *Transactions of the Faraday Society*, 1915, Vol. CVII, p. 1531.

⁶ *Transactions of the Faraday Society*, 1915, Vol. XI, No. 1, and No. 11, 1916, and *Transactions of the Chemical Society*, 1915, Vol. CVII, p. 1531.

centage of chromium in those alloys which resist corrosive attacks.

Nickel steels are another series of materials which have a definite resistant action toward corrosive media, and in this case the conditions are very similar to those holding in the case of chromium. In these steels the

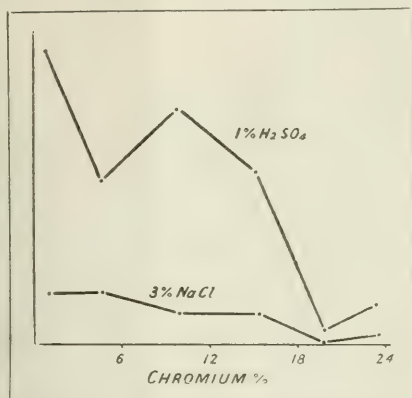


FIG. 2—CORROSION CURVE FOR CHROMIUM STEELS

nickel does not enter the carbide to any extent until more than 8 per cent is present, and hence there is produced a solid solution which contains a reasonably large percentage of this element. Thus in the two best-known examples of anti-corrosive steel the conditions demanded by theoretical consideration are fulfilled.

Yet another example may be put forward. In the steels containing cobalt there is found to be a fall of corrosion with an increase in the percentage of the cobalt. This is remarkable in one sense, because in the steels containing the higher percentages of cobalt the carbides had decomposed and precipitated graphite, a material calculated to cause a violent increase of corrosion if the solid solution has a suitable solution pressure. This increase of corrosion, however, does not take place, and this can only be due to the reluctance of the solid solution to act in an anodic manner. As the percentage of cobalt in the solid solution is found to be quite high, this is not surprising if the theory of the influence of electromotive force be allowed.

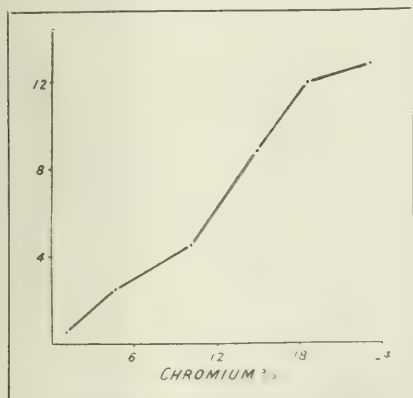


FIG. 3—SHOWING CHROMIUM PER CENT IN SOLID SOLUTION AGAINST CHROMIUM PER CENT IN STEEL

Another case is that of the vanadium steels. The curves for the corrosion of these steels are shown in Fig. 4, and it will be seen that there is an increase in the corrosion up to the steel containing 5.84 per cent of vanadium. After that the corrodibility decreases very appreciably. This is what might be expected in view of the composition of the solid solution. No vanadium is to be found in the solid solution up to the saturation point of the carbide, which is about 5.4 per cent of vanadium in the steel. At 5.84 per cent the solid solution is found to contain 1 per cent of vanadium, at 10.3 per cent it has 3.8 per cent and at 13.45 per cent as much as 7.2 per cent. Hence some distinct influence upon the electromotive force might be expected in consequence of the change of composition. If this change of solution pressure has resulted, then there will be a fall of corrosion, such as is actually found to happen.

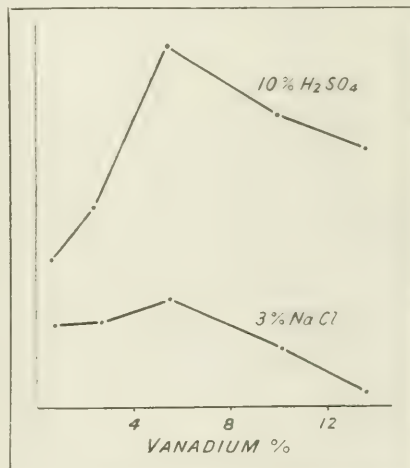


FIG. 4—CORROSION CURVE FOR VANADIUM STEELS

In the other steels examined—*e.g.*, those containing molybdenum and tungsten—there is no resistance to corrosion to be found. The compositions of the solid solutions in these cases show that there is never a formation of anything approaching a concentrated solution. In the molybdenum steels, the one containing 20.7 per cent of molybdenum has a solid solution in which the percentage of molybdenum is about 2.2. In the tungsten steels there is no tungsten to be found in the solid solution up to about 12 per cent, and beyond that only a small proportion, since the tungsten associates itself with the carbide part as both a double carbide of iron and tungsten, and also as a tungstide of iron. As a result one would not expect that these steels—*i.e.*, containing molybdenum or tungsten—would have any great resistance to corrosion, and this is found to be the case. These experiments all appear to support the theory that the corrosion of a steel is determined mainly by the solution pressure of the solid solution which the steel contains.

The microstructure of these ferro-alloys are also a powerful support of this same theory. The idea has been held for a long time that non-homogeneity in a steel is the primary factor in producing corrosion. This may be correct within certain limits, and given a satisfactory definition of homogeneity, but it is generally assumed in consequence of this idea, that a steel possessed of a complex structure is bound to be corrosive.

This view can no longer be held in face of the structure of the chromium steels that resist corrosion so successfully. The structure of a non-corrosive chromium steel is shown in micrograph No. 4, and it may be seen at once that this steel is quite the reverse of homogeneous, being composed of a very intimate mixture of solid solution and carbide. Here the number of possible galvanic couples per square centimeter of exposed surface is enormous, and everything that could be an aid to corrosion is apparently present. Yet there is no corrosion in weakly attacking media. This can only be due to a lack of power to go into solution on the part of the solid solution—that is, to a negligibly small solution pressure with respect to these media.

Again, take the case of a material of conspicuous chemical homogeneity—the bar iron illustrated in photograph No. 3. Here there is corrosion to an appreciable extent, and this can only be due to a difference of solution pressure among the constituents of the material, as stated above.

A further example may be quoted, that of a solid solution in which twinning of the crystals is present. The microstructure revealed by corrosion in this case is illustrated in micrograph No. 5, and this steel corroded to a very considerable extent. In this case there could be no lack of chemical homogeneity, the only difference between the various parts of the crystals being one of orientation, which would be reflected by a variation of the solution pressure. Yet the mere fact of twinning does not necessarily produce a corrosive solid solution, for some of the nickel steels containing a considerable percentage of nickel have twinned crystals in abundance, but yet only corrode very slightly. Surely these facts support the theory that the solution pressure of the solid solution is the important factor in deciding the corrosion or non-corrosion of a steel.

Following upon the action first of carbides and then of solid solutions (including ferrite) comes the behavior of pearlite—the remaining constituent of steels. This component in the structure of steels is, of course, a mixture in definite proportions of ferrite (or solid solution) and a carbide (simple or complex). Two actions are possible with respect to this constituent—it may act either as a mixture or as a whole. Both these opinions have been held. Viewing the matter from the point of view of the solution pressure of the constituents, it is a little difficult to see how the pearlite can act as a separate simple constituent. The potential of a eutectic, or a mixture, is that of the constituent having the greater solution pressure (that is, the one showing the greater tendency to become ionic), and in the case of pearlite this undoubtedly is the ferrite. If, then, the pearlite be acting as a whole, it should corrode in accordance with the potential difference set up between itself and the neighboring component, which is the large areas of the ferrite. But if the pearlite be regarded as a whole, then the solution pressure of the pearlite and of the ferrite will be the same, or almost the same. Hence there should be no corrosion. Also, if there were corrosion, then there should be a preferential attack upon either the ferrite or upon the pearlite.

Taking the other view, that the pearlite acts not as a whole, but as a mixture of ferrite and carbide, then the corrosion proceeds in accordance with the usual potential difference set up between these two constituents. This will mean that in any particular grain containing, *e.g.*, ferrite and pearlite, the two components of the galvanic couple will be the carbide on the one hand, and the ferrite forming the body of the grain on the other. Hence, as the whole of the ferrite in the grain is part of the same electrical unit, whether it belongs to the pearlite or to the ferrite, the anodic action should take

place all over the ferritic surface exposed to the corrosive liquid. In this way the ferrite will dissolve all over the surface of the grain, and the carbide will be unattacked.

If a series of pearlitic steels of different carbon content be corroded, and then examined microscopically, it will be found that the resulting structures are almost indistinguishable one from the other. In no case, after an attack of about ten days, can the pearlite structure be observed, and, except for the attacks at the crystal boundaries present in a bar iron and absent in the steels, the pearlitic steels all present the appearance of a corroded iron. The carbide has disappeared, unless a fairly large piece is present when it is left standing in a field composed apparently of badly pitted and corroded ferrite. There is no trace of a separate area of attack of ferrite in pearlite, and it is not possible to distinguish between a steel containing 0.4 per cent of carbon, and one with 0.9 per cent. A typical structure is that shown in micrograph No. 6, a steel with 0.89 per cent of carbon, after corrosion. This can only mean that the ferrite is attacked throughout, whether in the free ferrite areas or in those of pearlite.

The carbides will not have been attacked, this having been proved by many experiments quoted above, and hence their disappearance from the steel can only be due to mechanical means. This, of course, is quite a probable explanation of the action which has taken place, the ferrite being attacked by the corrosive liquid and dissolved away. This removes the support which held the carbide in position, and allows it to fall out during the washing which must necessarily precede microscopic examination after corrosion. The presence of the loose carbide on the surface of a corroded sample that has not been disturbed is usually fairly obvious. If the carbide is massive, it is like to be rooted more deeply in the mass, and hence on light corrosion is not removed.

This accounts for the structure of the steel shown in microphotograph 1, in which the carbide of the crystal boundaries (the cementite) remains clear and unattacked, while that of the pearlite, which normally occupies the body of the crystal, has disappeared. In some of the alloy steels which contained pearlite, and were examined, the corrosive action had not gone far enough to remove all the carbide of the pearlite from its matrix, and traces of the pearlite structure might be still seen in the resulting microsection.

The conclusions to be drawn from the above may be summarized as follows:

- (1) That the corrosion of a steel takes place purely by the action of the ferrite or the solid solution.

- (2) That the action upon pure ferrite may be due entirely to the potential difference set up in consequence of the different solution pressures of the grains of the metal and the inter-granular cement, it being probable that this latter is possessed of a greater electromotive force.

- (3) That the percentage of the third element added to iron and carbon in steels must be sufficiently great to produce a fairly high percentage in the solid solution, if there is to be any beneficial effect from the use of this element.

- (4) That the electromotive force of the solid solution with respect to the corrosive liquid is the deciding factor in the corrosion of a steel.

- (5) That the pearlite in a steel does not corrode as a whole, but as a mixture of ferrite and cementite, the disappearance of the latter being due to mechanical, and not to chemical action.

- (6) That carbides are not decomposed by ordinary corrosive agents, and that they act merely as cathodes to the anode of the ferrite or solid solution.

Concentration and Flotation of Lead Ores in Southeast Missouri

(Editorial Correspondence)

General

The region of disseminated lead ores in Southeast Missouri is the oldest of the large lead-producing districts in the United States. Production from ores in the lower Bonne Terre dolomite is recorded as early as 1869, though earlier production was made from shallow surface pockets. The principal towns of the district are Bonne Terre, Desloge, St. Francois and Flat River, and the producing area is included within a radius of five miles from the vicinity of Desloge-St. Francois. The operating companies are the Federal Lead Co., St. Louis Smelting & Refining Co., Desloge Consolidated Lead Co., and the St. Joseph Lead Co., which also controls the Doe Run Lead Co. To the managers and technical staffs of these companies we are indebted for many courtesies extended and for information on recent concentrating practice in the district.

Six concentrating mills are operated by the four concerns named. A seventh will be in operation this Fall when the new 2500-ton mill of the Federal Lead Co. will be completed. Further addition to the gross mill capacity of the district will result from changes in flow-sheet and equipment at the St. Louis company's mill which will treat 4000 tons per day. The various mills and their approximate daily capacities are listed below.

Name of Company	Mill Capacity Tons in 24 Hr.
Federal Lead Company	5,000
St. Joseph Lead Company, Bonne Terre	2,100
St. Joseph Lead Company, Leadwood	1,300
St. Joseph Lead Company, Rivermines	4,200
St. Louis Smelting & Refining Company	2,500
Desloge Consolidated Lead Company	1,800
Total	17,500

Similarity in the nature and occurrence of the ore on the different properties gives rise to practical uniformity in the methods of concentration, so that except for a few minor variations the milling methods bear a close resemblance to each other. This is true not only of past practice but also in the changes and improvements that are being introduced. The district being comparatively small and compact and the conditions reasonably uniform, the problems of the several companies are similar, varying mainly in degree. This accounts for the general use of the Hancock jig, the gradual adoption of the Butchart table or system of riffing, and the similarity in flotation equipment and practice at all mills.

Crushing and Grinding

The mills are usually erected adjacent to working shafts and the coarse-breaking plant is housed in the mill structure. In other cases run-of-mine ore is crushed at isolated shafts and the crushed ore transported to the mills. Gyratory crushers in large and medium sizes find favor for primary and secondary crushing and are generally adopted. The well known advantages of this type of breaker in handling a large tonnage of ore that is not too wet and sticky, with favorable power consumption and labor attendance, make it a desirable machine where run-of-mine does not come in too large pieces.

A departure from the general use of gyratories, however, is being made at the new coarse-crushing plant of the St. Louis mill, where a Traylor jaw breaker, 30 in. by 60 in., is being installed. The St. Louis mill was built in 1900 to treat 1200 tons of ore per day, but is now handling 2500 tons, with a prospect of 4000 tons when certain changes are made. The weak point in the

system, even at the lower tonnage, was the gyratory equipment which had insufficient capacity on run-of-mine ore, since many of the rocks were too large to be nipped. Capacity could have been increased with the present equipment by screening out the fine, but even then the large pieces would give trouble. It became practically necessary, therefore, either to build a new crushing plant with coarse breakers large enough to handle the big rocks, or remove the fine by screening and crush the oversize to say 4 in. or 5 in. for the present gyratories. A large gyratory could have been used, but in order to handle the large size feed its capacity would have to be unnecessarily great. Consequently the jaw crusher was adopted for primary work, since it would take larger size rock than a gyratory, considering equal capacities for the two machines, and also permit the continued use of the present crushing plant. The large opening of the jaw crusher was the decisive factor in its selection.

At the Federal mill gyratories are used as primary crushers to about 3½ in. and are followed by Symons 48-in. disc crushers giving a ¾-in. product. Similar equipment will be used at the same company's new mill. Where run-of-mine comes unusually large, a good sequence of crushing machines would be jaw breaker, gyratory, disc crusher and rolls.

Rolls are generally used for fine crushing and re-grinding, and at two of the mills, the Bonne Terre which is the oldest in the district, and the Desloge, the old Cornish geared rolls are still in use. The first introduction of the modern ball-mill for re-grinding is being made at the Rivermines mill of the St. Joseph company, where an 8-ft. diameter Marcy mill operated by a 200-hp. motor is being placed. This machine will be used for re-grinding certain screen oversizes and jig middlings and will be substituted for rolls. The installation is of an experimental nature to determine the efficiency and economy of the modern mill, and its further use will depend on the results obtained from its operation.

Screen-Sizing and Jigging

Screen-sizing is not done on as elaborate a scale as it was before the Hancock jig displaced the Harz, and only one product is now prepared, the limiting sizes being generally 9 and 2 mm. Two types of screens are in use for this work—trommels for both coarse and fine separation, and flat shaking screens, the latter being used in some mills for 2-mm. separation. Most of the trommels are cylindrical, but a few of hexagonal form with horizontal shafts are still in use at one mill for fine work. The tendency, however, to adopt the flat shaking screen of the Ferraris type in place of trommels for screening fine sizes, is in line with the claims of some authorities for the advantages of flat screens. The elimination of undersize grains is more readily accomplished due to lack of interference in their progress across the screen; and more frequent opportunities are afforded the particles to pass through the apertures by reason of frequent changes of position during their travel.

At one of the mills jig feed is prepared by drag classifiers which receive the undersize of 9-mm. trommels. In this case the fine material from the drag is prepared for table and flotation treatment.

As stated before, the Hancock jig is used in all the mills, having entirely displaced the Harz type. Its advantages are well known, but may be briefly reviewed. It will be apparent from the remarks on screening that jigging is done without close sizing, the limits being 9 and 2 mm. The ability of the Hancock jig to effect a separation of mineral according to specific gravity,

practically regardless of size, has made it possible to dispense with the long trains of trommels which formerly were necessary to size the feed for Harz jigs. Further, the Hancock requires less floor space than a number of Harz jigs of equal capacity; it uses very much less water and consumes less power.

The grade of jig feed will range from 3 per cent to 5 per cent lead, and the tailing will run about 0.7 per cent. The escape of fine mineral in the tailing formerly involved a loss which is now obviated by the flotation process. Jig tailings are dewatered either by means of a wheel scoop or by discharging over a screen, and the slimy water is added to other slime pulps and thickened for flotation.

Changes in Table Concentration

In table concentration the two most notable tendencies throughout the district are the abandonment of close classification and the general adoption of the Butchart system of riffling.¹

In table feed the particles range in size from 2 mm. downward, being the undersize of a 2-mm. screen or the overflow of a drag classifier. Formerly this pulp was hydraulically classified into a number of products for sand and slime table treatment, but the present practice consists in desliming the minus 2-mm. pulp, making separation at a point as near 150-mesh as possible. The portion minus 2-mm. and plus 150-mesh is then distributed to sand tables without further classification and the minus 150-mesh grade is in some cases distributed to slime tables or directly thickened for flotation.

Among the desliming devices, which are of local design, may be mentioned the Delano, which is in process of patenting by L. A. Delano, superintendent of the Bonne Terre mill of the St. Joseph Company. Designed to make a separation at 150-mesh, this device has shown high efficiency in practice, yielding 96 per cent minus 150-mesh in the overflow and 93 per cent plus 150-mesh in the underflow.

With the Butchart system of riffling, hydraulic classification other than desliming is unnecessary. The point at which the slime separation is made must be determined for each ore; but once determined, an unclassified feed is tabled successfully. The capacity of a table under the new system of riffling is greatly increased over the old, and water requirement is much less. At the Bonne Terre mill eighteen tables re-riffled according to the new system are treating a slightly larger tonnage than was formerly handled on fifty-two tables with other riffling, showing an increase in capacity of about three times. At the same mill, also, all jig and table concentrates are combined and re-treated over tables with Butchart riffles. The combined concentrates are separated at about 150-mesh into fine and coarse grades by a Delano deslimer, and re-treated over separate tables. The fine yields a product containing 80 per cent lead, and 75 per cent of the concentrate is finer than 200-mesh. The net effect of this re-treatment is to raise the grade of shipped concentrate from 62 per cent lead to from 75 per cent to 77 per cent.

Another factor in the success of the new system of riffling is the means for rapidly separating the stratified mineral without overloading a cleaning zone. It is also reported that large variations in the rate of feed can be tolerated, up to 10 tons per day, without requiring adjustment of the table.

A notable effect of the changes in classification and table treatment is the reduction in quantity of mill water used. Where the changes have not yet been

made, and the old systems still prevail, it is observed that the slime thickening equipment ahead of flotation is overburdened with an excess of water.

General Practice of Flotation

Flotation is practised at all the mills in the Lead Belt, and as might be expected in a district where conditions at the several mills are similar, the methods employed and results obtained are quite uniform. The average tonnage treated by flotation is from 12 per cent to 15 per cent of the ore milled, or between 2000 and 2500 tons per day. Some of this tonnage represents a former waste, and part of it was concentrated on vanners or canvas plants, which have since been abandoned.

It is customary to collect all slime pulps from jig and table tailings, classifier overflows, etc., and combine them into a flow to Dorr thickeners, where flotation feed is prepared. No acid or heat is employed at any of the mills, nor are chemical addition agents of any kind necessary. The water used in milling is pumped from the mines, and owing to the limestone and dolomite formations from which it comes it is very hard. The same oil is used at all mills, known as No. 2 creosote, prepared by the oil department of the Cleveland-Cliffs Iron Company. This is probably a mixture of wood creasote and other oils, and is used as received. The cost is about 14 cents per gallon, and consumption varies from 0.5 to 0.75 lb. per ton of feed.

Three types of flotation machines are in use: Minerals Separation and Janney agitation machines, and air cells like the Callow. The first two types are used for the main treatment, and their tailings are re-treated in air cells without further addition of oil. The only instance of recleaning flotation concentrate is at the Federal mill, where the froth from an air cell is re-treated in a single-cell Janney machine.

Most of the agitation machines are composed of sixteen cells, all provided with settling and flotation compartments. An exception to this general rule is the twenty-four-cell Minerals Separation machine at the St. Louis mill, two cells of which are used for mixing and agitation only, with twenty-two yielding a froth. With one or two exceptions all machines are belt-driven and require from 4 to 4½ hp. per cell. It is customary to use small pumps to deliver the oil to the machines, adding it at every second or third cell.

The grade of flotation feed will range from 2.5 per cent to 3 per cent lead. Concentrates from agitation machines contain from 65 per cent to 45 per cent lead, ranging downward from the first compartment to the last. The product of the air cells which re-treat tailings from the agitation machines is lower in grade, running from 20 per cent to 40 per cent lead, according to the material treated. Final tailing contains from 0.2 per cent to 0.5 per cent lead. All flotation concentrates are combined into one product, not only from the individual cells of the agitation machines, but also from the latter and the air cells. This gives a final product containing from 47 per cent to 52 per cent lead.

In the operation of the air cells a steady supply of air at from 5 to 7 lb. pressure, delivered by a blower specially provided for the purpose, has been found essential to good work. Where blowers have not been installed air is taken from the high-pressure air line through a pressure-reducing valve, but the result is not as satisfactory as with air from a low-pressure blower. The latter gives a steadier supply than the other method, and makes the work of the cell more uniform.

Handling Flotation Concentrate

The dewatering of concentrates is accomplished by first thickening in Dorr thickeners. At some of the

¹Transactions, American Institute of Mining and Metallurgical Engineers, Vol. 21, 1905, 1906, 1907, 1908, 1909, 1910, 1911, 1912, 1913, 1914, 1915, 1916, 1917, 1918, 1919, 1920, 1921, 1922, 1923, 1924, 1925, 1926, 1927, 1928, 1929, 1930, 1931, 1932, 1933, 1934, 1935, 1936, 1937, 1938, 1939, 1940, 1941, 1942, 1943, 1944, 1945, 1946, 1947, 1948, 1949, 1950, 1951, 1952, 1953, 1954, 1955, 1956, 1957, 1958, 1959, 1960, 1961, 1962, 1963, 1964, 1965, 1966, 1967, 1968, 1969, 1970, 1971, 1972, 1973, 1974, 1975, 1976, 1977, 1978, 1979, 1980, 1981, 1982, 1983, 1984, 1985, 1986, 1987, 1988, 1989, 1990, 1991, 1992, 1993, 1994, 1995, 1996, 1997, 1998, 1999, 2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019, 2020, 2021, 2022, 2023, 2024, 2025, 2026, 2027, 2028, 2029, 2030, 2031, 2032, 2033, 2034, 2035, 2036, 2037, 2038, 2039, 2040, 2041, 2042, 2043, 2044, 2045, 2046, 2047, 2048, 2049, 2050, 2051, 2052, 2053, 2054, 2055, 2056, 2057, 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mills an Oliver filter is used to further dewater the Dorr product, while at others the Dorr discharge is dried in shallow wooden tanks with steam coils in the bottom. The latter expedient is resorted to even if the filter is used, since it has been impossible to obtain a filter cake with less than 14 per cent moisture, whereas the smelters set a limit of not more than 7 per cent. Steam drying, therefore, appears at the present time to be a necessity in this district.

The general effect of flotation has been to increase the saving of lead, simplify the flow-sheet of the mills, and in some cases, to eliminate canvas tables, vanners or other tables for concentrating slime. Reciprocating tables are still in use in some mills for slime concentration, and in such cases the tailings from these tables are floated. The re-treatment of old slime tailing dumps is another development made possible by flotation. At the Rivermines mill an old slime pond is being reclaimed by hydraulicking and pumping to Dorr thickeners, where the pulp is combined with current slime tailings. The hydraulic water lines and pumps are operated from rafts on which the machinery is housed, the rafts floating in natural sumps in the pond to which the slime pulp gravitates as it is dislodged from the surrounding banks by the hydraulic streams. Pumps are belt-driven from motors, and flexible connections are made between the pumps and permanent pipe lines along the edge of the pond.

The consistency of flotation feed varies somewhat at the different mills, but in general is three parts water to one of solids. At the St. Louis mill the ratio is 6:1, which is the thinnest pulp treated. It is at this plant also that the twenty-four-cell machine is used, and while an oil consumption slightly higher than the average is admitted, a lower tailing, 0.2 per cent lead, is claimed.

The foregoing memoranda on flotation are general for the district. More detail of operation can be given on the work of the St. Joseph company at the Bonne Terre mill, where no other form of slime concentration is practised.

Flotation at the Bonne Terre Mill

The overflow from the Delano deslimers, together with other waste slimes from concentrating machines, representing about 15 per cent of the daily mill feed of 2100 tons, is thickened in five Dorr thickeners, four of which are 40 ft. by 8 ft. and one 44 ft. by 6 ft. They run at the rate of one revolution in ten minutes, and the discharged pulp has a water:solids ratio of $3\frac{1}{2}$ or 3:1. A screen test of the discharged solids will show from 95 per cent to 97 per cent finer than 150-mesh and from 88 per cent to 90 per cent finer than 200-mesh.

The thickened pulp flows to a sixteen-cell Minerals Separation machine, the impellers of which run at 300 r.p.m. The power requirement is 72 hp. Oil is added at every other agitation compartment, beginning with the first. Formerly the entire quantity of oil was added at the first agitator but experience showed that subsequent additions were necessary before treatment was complete, so the practice was adopted of distributing the oil to successive compartments as needed to make a good recovery. A slight difference is noted in the results obtained in winter and summer, the latter showing an improvement, but the difference is not sufficient to warrant the expense of heating the pulp. The consumption of oil is 0.7 lb. per ton of feed.

Froths from all cells are combined into one product, even though the grade of concentrate from the head compartments is higher than that from the other end of the machine. These products will range, respectively, from 65 per cent to 50 per cent lead. The tailing is elevated by centrifugal pump to an air cell for final treatment, and a concentrate containing from 30 per cent to

40 per cent lead is obtained and combined with the froth from the agitation machine. The average grade of the mixture is 52 per cent lead, and final tailing contains from 0.35 per cent to 0.5 per cent lead. Air is supplied to the final machine at 7 lb. pressure.

The flotation concentrate flows to a belt and bucket elevator, which raises it to a Dorr thickener, 38 ft. by 6 ft., running at the slow rate of one revolution in thirty minutes. Thickener feed contains 90 per cent moisture and discharge 40 per cent. Other means were tried for raising the pulp to the thickener, but the elevator was found best since it aided in breaking the froth when the buckets discharged their load. Pumps aggravated the frothy condition of the pulp and had to be abandoned. The froth is very persistent, and every means must be utilized to break it or avoid increasing it. Thus a spray of clean water is used over the receiving well of the thickener, and the incoming pulp is discharged above the surface, as this was found preferable to a submerged discharge. The use of oily water in the spray cannot be tolerated. Even with all precautions the accumulation of considerable dense froth on the surface of the thickener cannot be prevented, and from time to time it is removed by a hoe and again delivered to the elevator.

Filtration of Flotation Concentrate

The thickened pulp with 40 per cent moisture is further dewatered on an Oliver filter, which yields a cake $\frac{1}{8}$ to $\frac{3}{16}$ in. thick containing from 14 per cent to 15 per cent moisture. Persistent efforts and experiments have failed to lower the moisture in the filter cake below this point. On one occasion the entire filter was housed in a tight covering, and dry air at a temperature of 175 deg. Fahr. was blown into the inclosure in the hope of reducing the moisture content of the cake. The result was almost negative, for the moisture was not lowered appreciably below that obtained under normal conditions of operation. Heating the pulp with live steam also was tried, and while this did not effect a decrease in the moisture content of the cake, it had the unexpected and desirable effect of almost doubling the capacity of the filter, which up to that time was scarcely equal to the service demanded.

Since the smelters set a limit of 7 per cent moisture in concentrates, it is necessary to dry the filter product, as already explained, in tanks with steam coils in the bottom. As these tanks must be filled and emptied by hand, additional expense and delay in marketing are entailed by the process.

Oliver filters are in use at several of the mills and are being installed at others. The filter is a desirable machine, even if it cannot deliver a commercially dry product from this particular type of mineral slime, most of which is finer than 200-mesh. The drying of a 40 per cent moisture pulp in steam boxes is an expensive process, besides being slow, requiring additional labor and holding a large amount of concentrate in the process. The intermediate step of filtering to reduce moisture by 25 per cent, or 62.5 per cent of the total, must be more economical than attempting to remove the entire amount by heating.

Asphalt Industry in 1915.—According to the Geological Survey the asphalt industry enjoyed a prosperous year in 1915. Natural asphalt produced amounted to 75,751 short tons, valued at \$526,490, which was 5 per cent less than in 1914. The manufactured asphalt, however, made from domestic petroleum residues was 664,503 short tons, valued at \$4,715,583, or a gain of 84 per cent over 1914. There was also 388,318 short tons made from petroleum imported from Mexico.

Cost Accounting in the Construction and Operation of a Copper Smelter—IV

BY ERNEST EDGAR THUM, E. M.

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In previous instalments* of this series methods have been presented at considerable length for gathering information necessary for an adequate compilation of costs and accounts covering the construction and operation of a copper smelter. Lists of accounts into which it is necessary to segregate the expenditures have also been given. The discussion so far has been primarily devoted to subjects connected with accounts covering the money-cost of construction, repairs and reconstruction of the various mechanical and structural units comprising the complicated machine known as a modern copper smelter, e.g., buildings, furnaces, tracks and flues. Therefore, the more extensive subject of accounting for operating expenses has been mentioned only in passing; a list of useful operating accounts coordinating with the construction and repair accounts has been given, and it has been indicated how the account books, machinery and personnel of the construction cost-keeping bureau can be utilized by the operating departments.

It should again be emphasized that all time-cards, warehouse and shop orders should bear tersely worded descriptions of the particular detail of the job to which they refer, in addition to the appropriate account and sub-number. Only in this manner can the demands of both the cost-keeper and the auditor be fulfilled. The auditor could tell the manager the total cost of operating the blast-furnaces for any fiscal period, but the aid of the cost-keeper and metallurgist is required to discover the cost per ton of smelting rabble cleanings from the McDougall furnaces. Even their best efforts will be totally unavailing to produce important details of cost if the necessary information has not been gathered and noted on the spot and properly filed for future reference.

Progress in the metallurgical art results largely from an improvement of the details of a process rather than from a revolutionary change in the method itself, and in nearly all cases a revision of detailed practice is a success or failure in exactly the same measure as it decreases or increases the cost of the operation. How, then, can the manager be enabled properly to judge whether or not a variation in the routine would be desirable, if he is in ignorance of the cost of the old practice, and cannot discover the expense of the new?

Distribution of "Non-Productive" and General-Commodity Costs

The necessity for clear and adequate notations on all operating charges is particularly evident in such "non-productive" units as the power house department, which, as has been previously noted in the listing of operating accounts, cannot usually be adequately subdivided in the ordinary accounting system. The word "non-productive" is somewhat a misnomer, as the power house produces such valuable commodities as power, light, heat and blast. It is commonly used in accountant's parlance inasmuch as such departments are outside the continuous chain of smelting operations between ore and ingot; serving all, as need arises. The cost of operating the power house, therefore, becomes an "expense" to be absorbed by the "productive" departments.

The problem of determining the correct value and

proper estimation of the consumption of such widely used commodities is one of the most difficult for the management to solve, and becomes a mere matter of guesswork in many instances. However, if the proper care and attention has been bestowed upon the detailed labor and material charges day by day, the cost-clerks will be able to divide the sum total of the bookkeeper's account into parts representing the cost of producing high-pressure water, converter air, steam for heating and the dozen other kinds of power developed. Assuming that the plant is equipped with adequate meters, the reports of the power-house timekeeper will show the amount of each class of power "at the switchboard," whereupon the cost per horsepower, kilowatt, gallon or cubic foot can be immediately established. As demonstrated previously, these prices should evidently be fixed for a certain fiscal period and revised only at such long intervals (as experience with the profit-and-loss account will direct), in order to enable one to make rational comparisons of smelting costs, should they carry power charges.

Given the necessary data, then, the procedure will so far be comparatively simple, but the cost-keeper would seem to be in ignorance of what becomes of the power when it leaves the power house. Bear in mind, however, that time-cards for all large machines will be found on file giving a continuous history of their operations, as well as daily reports to the power-house clerk covering the operations of small tools and isolated equipment. Taking a concrete illustration, the amount of air consumed per hour per converter and its cost will be readily determinable—converter air is generated in a particular type of engine and is piped directly to the converters and used by them alone. But the electric power necessary for tilting is not so easy to fix—the driving motors are on a general power circuit supplying a 100-hp. motor at each converter operating 1 per cent of its time at 50 per cent overload, cranes with 300 hp. in motors operating 60 per cent of the time at 20 per cent capacity, motors for casting machines, ventilators, elevators, and so on, each operating under different conditions and load factors.

The total electricity furnished this circuit might have been metered at the substation, but the final destination will be at first a matter for the chief engineer's or master mechanic's best judgment. No time should be lost after operations are running along smoothly to check up and revise such estimates by a painstaking determination of the actual average power consumption of all machines, furnaces and departments. If properly made, the quantities so determined can be maintained as a fixed charge per hour on the time-card of every machine, and the sum total of all such for the month should balance within limits with the total output of the power-house. Any large discrepancy will be a signal for an investigation; the error will be corrected, or the leak quickly stopped. The time of a well-trained engineer could not be better invested than in continually watching the power distribution throughout a large smelter. The prime object of his labors would not be the construction of a nice power balance-sheet, but the detection and elimination of leaks; one large one discovered and corrected will save his salary for an indefinite period. Under his care it would be unnecessary to compress 800 cu. ft. of blast for every 100 blown through the tuyeres of the blast furnace, a condition reported by a recent metallurgical text.

All commodities used in the concentrating, smelting and refining processes should be as carefully watched and accounted for as the power accounts alluded to above. Water, for instance, costing thousands of dollars to develop, store, pump and deliver should not be

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turned loose at the rate of 50,000,000 gal. a day to the tender mercies of table and jig, sluice and cooling jacket without at least knowing how much of it each machine needs, and then seeing to it that one machine operative does not extravagantly waste another's portion. Such knowledge and supervision is the first step toward efficiency because it will lead naturally and quickly into comparative tests of alternative types of apparatus with the development of new schemes for saving money by the conservation of even such an ordinary commodity as water.

Special Attention Required for Gathering Information

The usual method in vogue in smelters of requiring straw-bosses to make out the time-cards would be entirely inadequate for the prosecution of the system here outlined. Owing to a press of more important duties connected with "getting the copper" he will fill in his reports and make up the time-cards in the hasty manner—shortly falling into the habit of jotting down merely the account number and sub-letter, failing even to properly distribute the time in case his men are working on more than one subdivision. Time-keeping and clerical work should not be expected of a foreman any more than responsible supervision should be asked of a clerk.

The method outlined for gathering information during construction should therefore be followed after the plant has been blown in; and, in general, it would be a wise policy to retain as many of the trained construction staff as will be necessary to handle the simpler and much more steady routine of operation.

The timekeeper assigned to each department should make a tour early in the shift, gathering the time-cards from the straw-bosses, noting at the proper place in his loose-leaf note-book the detailed information necessary to adequately describe the kind of work each man is doing and all unusual conditions which may surround the work. From the shift-boss and sampler he notes the number and time of machines, furnaces, converters or other large machines in operation; he makes a rough estimate of the amount of raw material (such as ore) in the bins and finished material (such as concentrates) ready for delivery, visits various indicating meters and makes periodical notations of their readings and changes and preserves charts on recording meters.

Such tours for inspection and information are repeated at intervals of two hours exactly as outlined previously in this discussion. During the day the timekeeper visits the warehouse and shops to examine the charges on current orders and makes out the time-cards for workmen and machines, in general, carrying out the routine learned during construction.

One of the duties to be performed early in the shift is to make a statement of conditions in the department at the beginning of the shift, appending necessary explanatory remarks, which is inspected carefully and initiated by the department foreman before being forwarded to the general foreman's office. The statements from all departments are here collated and condensed into a general tabulation of operating conditions for the information of the management. This general statement also bears information as to the amount of major supplies consumed and principal products produced, gleaned from reports of the transportation, unloading and tramming departments and of various scalemen placed at proper parts of the plant. Such a summary statement of operations, shorn of numerous minor details, is given in Table I.

Accounting of Metal in Process

A consideration of our dictum that all commodities

TABLE I.—GENERAL SMELTER REPORT

McDougal Plant, Texas		
Next day's report	18	
Charges		
Fuel	141	tons
Lime	117	tons
Lime (slag)	7	tons
Flux	140	tons
Oil	7	tons
Tons per square foot of hearth	1.4	
Time lost	1.4	hours
Converter Department		
Number of charges	21	
Nuts to producers	23	
Coke	40	tons
Nuts	82	tons
Lime	1	ton
C.H.	1	ton
N	58.0	
C.O.	23.0	
C.O.	3.0	
O	14.8	
Caloric power	14.8	tons
Reverberatory Department		
Number of furnaces running	1	
Number of taps	15	
Number of charges	15	
Charges		
Caloric	388	tons
Flux dust	127	tons
Fine lime rock	0.26	tons
Tons per square foot of hearth	4.4	furnace hours
Time lost	4.4	hours
Blast Furnace Department		
Number running	5	
Taps	38	
Car loads charged	1,978	
Materials charged		
First class ore	538	tons
Coarse concentrates	421	tons
Custom ore	137	tons
Converter slag	146	tons
Limestone	676	tons
Coke	144	tons
Tons per square foot of hearth	10	per cent of whole
Time lost	10	furnace hours
Converter Department		
Number of charges	1	
Converter changed	1	
Number of errors	1	
Cranes operating	21.2	converter hrs.
Time lost	21.2	converter hrs.
Pots of slag cast	260,000	lbs.
Copper made	260,000	lbs.

used in the concentrating and smelting process should be carefully watched and accounted for, leads us naturally to the thought that an accounting of the actual metal in process should show strikingly valuable information as to the operations in general, and the efficiency of small units in particular. This is entirely beside the idea held in some large organizations that each department should operate as a separate business concern, paying for what it uses and selling what it produces; and above all, operating at a profit. Evidently, under such a system, a knowledge of the metal consumption and production of the department as a whole is absolutely essential. The routine for the production of such information will now be outlined.

The concentrating department stands at the head of those necessary to turn ore into metal. Its receipts are low-grade ore from various mines and localities. The quantity of this ore is had from the transportation and unloading department reports showing the weight, point of origin and point of unloading of each carload or parcel of material. The consumption of these receipts is determined roughly by the daily receipts, less the estimates of the timekeepers of the amount of this material in the bins, and is adjusted monthly to accord with the careful inventory estimates made by the engineering staff of all quantities of ore in the concentrator bins, storage bins, stock piles, bedding system and any other place where material is held preliminary to treatment. The quality of the ore is a matter for the sampler and the chemist to determine. In case the ore comes from the company's own mines, the sampling and assaying is usually done at the point of origin. Foreign and custom ores are to be sampled in the ap-

proved manner. A discussion of the various arrangements of automatic machinery for such large quantities of material is beside the scope of this paper, for it has been excellently handled elsewhere by expert engineers who have given this particular branch of concentration their whole time and attention.

The metal accountant is enabled by a judicious use of this information at his disposal (i.e., inventory, receipts and analyses) to compute the consumption of the concentrator of copper, gold, silver, sulphur, iron, silica, alumina, lime, zinc, lead and any other substance which is a benefit or a detriment to the subsequent operations and which must, therefore, be either converted or eliminated to the fullest possible extent.

The production of the concentrator falls into four main classes, to wit, coarse concentrates, fine concentrates, slimes and tailings, each of which may possibly be differentiated as to the section of the mill which produced them, size, value or other characteristic. Leaving such variations out of account, the specific case of the disposition of coarse concentrates will best describe the general method of accounting for the production.

Specific Case of Coarse Concentrates

The coarse concentrates are laundered directly to the storage bins and sampled en route by automatic machines diverting the whole stream at regular intervals for a small period of time into a small tank placed nearby. This sample is collected by the sampling department, drained, weighed, dried, further cut down, ground and prepared for analysis in an approved manner. The analysis by the laboratory is forwarded to the metallurgist and the concentrator foreman, together with information as to the point of origin of the sample and the shift which produced it, and is scrutinized by them in the light of past performances and the ideal in mind to be attained.

The quantity of coarse concentrates is derived from the scaleman's reports, who records the weight, point of origin and destination of each carload drawn from these bins. The total of these weights should check with the amount of concentrates produced as derived from the weight of the sample obtained per shift; which, being gathered by automatic machinery, will represent a certain percentage of the amount of solid matter passing the sampler during its operation. At monthly intervals the engineers will make careful estimates of the quantity of concentrates on hand in each bin; these inventories, the scale weights of material trammed and the sample weights will allow the metal accountant to compute the production of coarse concentrates month by month.

Note that the metal accountant does not receive the daily routine analyses of materials in process, made as noted above. Instead he usually receives merely the analysis of the "monthly sample" representing the average of all coarse concentrates produced during the month. This sample is made up in the sampling department by preserving the same small fraction of each shift sample; this sample being proportional to the production for that shift. At the end of the month all of this material combined will represent a weighted average of the production for the month. The analysis when multiplied by the gross monthly production will give the quantity of each metal or oxide produced in this particular commodity.

The daily samples of the coarse concentrates may vary within limits around 12 per cent copper; the variation is a matter of concern for metallurgist and millman, but the metal accountant gets only the analysis of the monthly sample, which may read:

Moisture.....	5.75	per cent
Copper.....	12.22	per cent of the dried sample
Silver.....	3.90	ounces per ton
Gold.....	0.018	ounces per ton
SiO ₂	20.73	per cent
FeO.....	33.25	per cent
S.....	33.75	per cent
Al ₂ O ₃	4.40	per cent
CaO.....	0.28	per cent

From a consideration of his various weights the metal accountant arrives at the conclusion that 18,020 tons of coarse concentrates have been produced, which figure as follows:

Dry weight.....	33,968,691	lb.	a
Copper.....	4,154,638	lb.	
Silver.....	66,245	ounce	
Gold.....	311.5	ounce	
SiO ₂	7,037,466	lb.	
FeO.....	11,315,604	lb.	
S.....	11,475,725	lb.	
Al ₂ O ₃	1,493,861	lb.	
CaO.....	96,941	lb.	

This represents the total production as coarse concentrates for the period in question, and these figures are placed on his balance sheet in the proper places.

In a similar manner the fine concentrates, slimes and tailings are automatically sampled before reaching the storage bin, the resulting sample being a measure of both the quantity and quality of the product. In the case of fine concentrates, the weights of the carloads trammed from the bins to the calcine or other departments will serve as a check upon the production. In case the slimes are retreated, the metal in the slime plant is carefully accounted for in a similar manner as in the concentrating department, and these figures will serve as a check against slime production in the concentrator. Slime ponds and slime storage piles may be inventoried by quantity estimation by the civil engineering staff at intervals of twelve months in case the accumulation is very large, although, in general, monthly estimates will involve no more work in the totality. For estimates of the amount of tailings, reliance must be placed on the weights of the product of the automatic samplers; a check may be had by figuring all material not otherwise accounted for as tailings. Such a proceeding should be followed with circumspection, as it is liable to lead to numerous inconsistencies in the final figures for the various substances; but worse, it will cover up a multitude of sins of omission.

Accounting of Furnace Materials and Products

More attention is usually paid to the metal accounting of the furnace departments' receipts than elsewhere in the plant, for even in the most carelessly run plant, smooth working of the furnaces demands a properly balanced and weighed charge. The blast-furnace storage bins, for instance, may contain sections for first-class ore, second-class ore, custom ore, lime rock, briquettes and coke, each of which is weighed and sampled before delivery and which is drawn out in definitely weighed quantities in making up the furnace charges. With the aid of the monthly inventory, this material can be closely accounted for, as can also such intermediate and retreated products as concentrates, calcine barrings, converter and refinery slag, matte and smelter cleanings.

After once entering the furnace, however, the adequate tracing of the material is not so easy. The ordinary products are matte, slag, flue-dust and fume. Of these the matte is most simple to estimate. The quality is determined by filling one or two small ladles from the stream when tapping a pot of matte from the furnace or settler, and forwarding the buttons cast from each furnace to the laboratory for analysis. The quantity is determined by taking the gross and tare

weight of each ladle as it goes to the converter department, either on a platform or track scale, or if handled overhead, by automatic scales hung from the crane. The weight of matte skulls shaken out of the ladles for retreatment is found similarly.

If granulated, the slag is sampled, estimated and analyzed similarly to the procedure for concentrator tailings. If handled in pots, the sampling is done in the same manner as sampling matte, and the contents can be weighed on the way to the dump.

Difficulties of Estimating Flue-Dust and Fume

The estimation of flue-dust and fume is not so easy and in most cases the figures used are little more than guesses "by difference." Metallurgists have recently become very much alive to the fact that a close scrutiny of feasible methods of reducing the quantity of these elusive substances will pay handsome dividends, not only directly in values and retreatment charges saved, but indirectly in expensive "smoke suits" and damages averted.

By flue-dust is meant the finely divided solid matter carried in suspension from the furnace top by the more or less swiftly moving gases and which quickly settles as the velocity and carrying power of the smoke is reduced when passing through the larger flues leading from the furnace department. These flues are provided with hopper bottoms and large quantities of dust

vice should be used which will extract a representative portion of the passing gases without condensation of the fume, or loss of the very fine dust. A thorough study of the varying velocities of the different portions of the gas stream is also necessary in order that the curves drawn by the draft gage and recording thermometer may be transformed into cubic feet per minute.

Analytical skill and engineering ability of a high order is necessary to properly sample and estimate the conditions existing in the upper part of the flue system from dust chamber to top of chimney, but its expenditure will amply repay the company whose policy is sufficiently enlightened to realize the offensive and defensive value of accurate, complete and trustworthy information as to conditions in this part of the smelter. Flue and chimney jobs are usually dreaded by members of the staff, yet under proper design and management these units can become a veritable gold mine, and under the opposite conditions a theft of profits and a public nuisance.

Metallurgical Accountant's Balance-Sheet

The method of accounting for all furnace departments (roasters, reverberatories and blast-furnaces) is quite similar each to each, and need not be further dwelt upon. As a general illustration of a page from the accountant's balance-sheet, that covering operations of a McDougall roasting department is appended in Table II. It appears here in a condensed form from

TABLE II—McDOUGALL ROASTING DEPARTMENT
MATERIALS CHARGED

	Dry Weight, Lb.	Copper, Lb.	CaO Lb.	Al ₂ O ₃ Lb.	Sulphur, Lb.	FeO, Lb.	See Lb.	Gold, Oz.	Silver, Oz.
Fine concentrates	28,207,111	2,492,687	95,333	1,507,286	10,125,066	10,361,299	5,113,580	291.9	12,608.5
Fluorite, etc.	740,563	48,526	1,831	65,701	129,735	128,019	17,607	5.6	88.5
Slimes	928,966	25,462	2,317	189,881	41,792	40,896	550,005	2.0	30.9
Limestone	1,990,657	987	1,000,146	12,033	5,483	17,422	115,728	0.5	7.9
Total charges	31,867,297	2,567,662	1,099,627	1,774,901	10,301,976	10,548,236	6,136,918	300.0	44,254.3
MATERIALS PRODUCED									
Calcine	21,071,385	2,091,220	1,055,280	1,276,327	1,875,079	8,533,180	4,538,806	262.3	17,177.1
Clampans	171,904	13,823	561	6,179	7,024	107,710	10,091	1.7	230.3
Flue-dust	3,587,248	328,598	17,720	279,434	652,717	805,274	907,832	35.7	566.2
Total production	24,830,537	2,433,641	1,073,562	1,561,740	2,534,820	9,446,164	5,457,329	299.7	47,973.6
Losses	7,036,760	134,021						0.3	1,031.3
Percent loss	22.1	5.2							

GENERAL NOTATIONS

Furnace days worked	228
Tons treated per furnace day	63.7
Pounds per square foot hearth area per furnace day	149
Cost per ton	\$0.65
Disposition of product	

are drawn from them every day to be charged and re-melted in the reverberatory furnaces. Weighing and sampling this dust is a matter of routine. Inspection holes at intervals in the flue walls and roof are utilized by the engineers to make monthly estimates of the material in the flue, whence a balance on the quantity of dust deposited may be had. Incidentally, a monthly estimate of flue-dust in the system will prevent any overloading with accompanying disastrous results to supporting beams and columns.

Little of the fume and not all of the finest dust is deposited before the gases join smoke from other departments, or enter the main dust chamber. At the point of junction it will be necessary to sample and measure the quantity of gases from each department in order to fix the origin of the very fine material deposited in the main dust chamber or precipitation plant, as well as the gases and solids discharged from the main stack. A very carefully designed sampling de-

what would be desirable in practice, as ordinarily more than four different classes of materials are charged.

However, it is extensive enough to illustrate the form of such balance-sheets and will indicate some of the uses to which it may be put. For instance, there is a loss of 134,021 lb. of copper shown. The inquiring eye of the manager will immediately light upon this item. With the metal at a normal price of 15 cents a pound, this represents a value of \$20,000.00; evidently well worth hunting for. Doubtless a considerable proportion of this metal will be found in the fume, deposited in and above the main dust-chamber, and which item does not appear on this balance sheet. Yet, if all the products were accurately sampled and estimated, a roasting department (or any other department, for that matter) should show a true balance between the "treatment" and the "production." This, of course, represents an ideal which is unattainable owing to imperfections in the analytical and other processes involved, yet the aim of the entire technical staff should be to approach this ideally perfect balance more nearly each month. Would any auditor be content with his staff and organization should the money accounts of a cor-

poration, however big, show a leakage of \$20,000 a month; or accept the statement of the bookkeeper that he "thought it represented unavoidable wastage"?

Accounting in the Converter Department

The converter department receives a varied assortment of material which is sampled and weighed before delivery. Matte from the blast-furnaces and reverberatories is charged molten; each ladleful being sampled and weighed as described above. Ore, concentrates, matte skulls and various fluxes are sampled and charged from time to time in weighed boat-loads as the blow progresses. Scrap-copper from the refinery or outside sources used to cool the converter is handled and weighed by the boat. Spillings, accretions, floor-cleanings and other products originating and retreated in this department are not taken into account on the metal balance sheets for obvious reasons; however, a monthly inventory of such material will furnish the necessary information to appear on the balance as "material in process."

The main product of the converter department is, of course, anodes of blister copper. These are sampled by holding a flat, pan-like ladle over the freshly poured anode, catching the minute shot-copper which dances up from the surface during cooling. Anodes from each blow are carefully stacked up, cleaned of projecting fins and weighed over accurate scales as they are trucked into cars for shipment to the refinery. Converter slag is a more bulky product, which is handled and weighed between converter and slag-casting machines as it is transported by the overhead traveling cranes. Sampling is done by thrusting a cold iron rod to the bottom of the ladle and quickly withdrawing it—a thin layer of slag adheres which will easily shell off upon cooling. The gases and fume present the same difficult problem discussed previously and are handled in the same general manner. Converter spittings, accretions and other unfinished products are usually retreated as rapidly as they are formed, by charging them back into a blow, and, therefore, do not need to be analyzed or estimated, with the exception of any balance existing as "material in process" at the regular inventory.

The maintenance of such a system of metal accounting will cause small additional expense to the company. One or two young technical graduates stationed in each department about the works will gather the necessary samples, and in most cases may act as scalemen as well. Considerably more expense will develop upon the laboratory in order to run the necessary analyses; some little time will be required from the civil engineers at the first of each month to make the inventory, and at least one first-class bookkeeper will be required for the clerical work of tabulation. This organization, with the exception of the civil engineers, should be under the direct control of the metallurgist; who, of course, should be directly responsible to the management for the proper technical operation of the processes involved in metal recovery.

Value of the Metal Inventory

Doubtless the greatest value of the metal inventory will be its everlasting demand for perfection. In order that it may measure up to the standard maintained in the clerical department for the money accounts, the closest attention must be paid to the details comprising the basis of the metal accounts. In order that the account may balance, the *losses* must be located. It will test the cleverest wits to discover the location of some of these losses. But what is more natural than an effort to prevent them or at least curtail the unpreventable to the smallest possible amount? Unprevent-

able losses in large volume should immediately condemn a supposedly successful concentrator or furnace and will institute a vigorous search for a more successful substitute. No line of investigation will be more fruitful of real facts about a furnace process than a close study of the metal and material balances when these are constructed on a scientific basis.

As an actual instance of the value of such studies suggested by the author's experience, a certain concentrator section was guilty of producing what seemed to the metallurgist to be an excessive amount of slime. A squad of samplers and investigators (all young technical men) under the direction of a competent engineer, started out to find where the trouble lay. They investigated the production of slime from the unloading bins to the banner division and showed conclusively that the coarse-crushers directly in front of the ore-storage bins were the greatest offenders. In order to "get the copper" the crusher-men kept their machines choked all the time—in this manner not only cutting down the actual capacity of the crushers but largely increasing the fine produced. In this manner the Blake crusher actually produced a greater amount of fine per ton of material treated than did a Huntington mill. An automatic feeder was then designed and installed to feed each of these large crushers a steady stream of coarse material from which the large proportion of undersize had been removed. The crusher capacity was increased, the operating cost in labor and repairs decreased, and best of all, the amount of slime made by the concentrator showed a sudden and gratifying drop.

Cincinnati, Ohio.

Synopsis of Recent Chemical and Metallurgical Literature

Iron and Steel

Effect of Chromium in Hardening Steel.—Chromium is widely used in special steels, usually with other added elements. Experiments have shown, however, that a chromium steel has self-hardening properties, without the presence of tungsten and that within certain ranges of composition the element chromium has an even greater self-hardening effect than tungsten. Further experiments carried out along this line are described in a paper presented to the Iron and Steel Institute in London by Professors C. A. EDWARDS, J. N. GREENWOOD and H. HIKKAWA.

Previous experiments by Hadfield, Osmond and the present authors, had shown that the rate of cooling determined the self-hardening properties, and considering that marked differences of hardness were obtained at different rates of cooling the author thought it desirable to examine the following conditions: (a) At what critical rate of cooling this self-hardening property becomes manifest, (b) whether there are any variable factors which influence this critical rate, and (c) what is the nature of the thermal change, if any, under the conditions of cooling which produce hardening. In other words, to make a quantitative examination of, and extend upon the facts which were discovered so long ago by Messrs. Hadfield and Osmond.

The composition of the steel used in the experiments was as follows:

	Per Cent
Carbon.....	0.63
Silicon.....	0.07
Manganese.....	0.17
Chromium.....	6.15

The initial temperature to which the pieces were heated was found to have an important bearing on the self-hardening properties and its effect and the rate

of cooling were investigated with the following results.

This property of self-hardening is governed by the rate of cooling.

The critical cooling velocities which produce hardening varies with the initial temperature, being much slower as the temperature is raised. The extent of this variation has been determined for a wide range of temperature.

The appearance of self-hardening coincides with the presence of large quantities of martensite, and a diminution in the magnitude of the carbide thermal change.

The maximum hardness was obtained when the thermal transformation had been entirely prevented, and when this was accomplished the steel was purely martensitic in structure.

While, with the chromium steel which has been used, the cooling rates which produce hardening are extremely slow as compared with those which are obtained in the hardening of carbon steels by quenching, the two operations are fundamentally the same. In other words, a given rate of cooling which might be regarded as slow for carbon steels, really constitutes quenching in the case of some special alloy steels.

The precise cause of an increased initial temperature making the self-hardening more evident is not known with any certainty. The view which the authors provisionally hold at present is, that the chromium carbide (Cr_3C_2), which has been isolated by Professors Arnold and Read, first goes into solution as $(\text{Cr}_3\text{C}_2)_2$, i. e., Cr_6C_4 , and is then progressively dissociated into Cr_3C_2 as the temperature is raised. When the steel is again cooling these molecules only slowly reassociate, and thus the molecular effect of the dissolved chromium carbide is greater as the initial temperature and molecular dissociation increases.

Tungsten and Molybdenum

New Tests for Molybdenum.—In the March issue of the *Journal of the Chemical, Metallurgical and Mining Society of South Africa*, Dr. JAMES MOIR gives some new and sensitive tests for molybdenum. The first relates to the formation of a characteristic blue color which ordinarily appears as a fugitive tint in the first stage of reduction of molybdic acid by nascent hydrogen. The author has improved this test and secures a permanent blue color.

Hydrazine, N_2H_4 , forms in the writer's experience the best reagent for developing the blue color. A solution containing a trace of alkali molybdate when acidified with acetic acid and treated with a little hydrazine sulphate and boiled, rapidly turns deep-blue and retains this color on boiling. Hydroquinone may be used in place of hydrazine with much the same result. An analogous but more remarkable reaction, is that obtained when a slightly acid solution of MoO_3 is treated with potassium iodide (in some excess) and boiled for some time: iodine is slowly liberated and the solution turns blue. The use of phenylhydrazine for reducing molybdenum has been described by Spiegel and Maas (*Berichte*, 1903, p. 513), but the reddish coloration obtained is different and seems to contain phenylhydrazine. Simple hydrazine is an improvement.

The best known sensitive test for molybdenum is that in which the acid solution is treated with sulphocyanide and a tiny piece of zinc added, when a crimson coloration is obtained in a few seconds. If iron is also present the solution becomes blood-red on adding the sulphocyanide, but on adding the zinc this becomes colorless through reduction (to the ferrous condition) and after a few seconds becomes crimson if Mo is present. If the solution is strongly acid the coloration verges to red and is less sensitive; if nearly neutral the coloration

resembles that of permanganate. It is probably due to $\text{Mo}(\text{SCN})_3$. Another modification of the test for Mo in presence of Fe is to add stannous chloride to the acid solution until the yellow color just disappears and then add sulphocyanide.

Another well-known reaction for MoO_3 in the absence of iron consists in adding potassium ferrocyanide. Mineral acid must be present, and a russet-brown precipitate is obtained which still contains hexavalent molybdenum.

In the presence of acetic acid (not mineral acid) tannin (or gallic acid) gives a similar reaction, which has been known for some time. The writer has improved this by substituting pyrogallol or pyrocatechol for tannin. Either of these when added to a molybdic acid solution previously treated with sodium acetate gives a very sensitive orange coloration.

The System Tungsten-Molybdenum.—The following summary of the essential points in a research conducted by FRANK A. FAHRENWALD, is taken from the June *Bulletin* of the American Institute of Mining Engineers. The alloys of tungsten and molybdenum have received little consideration in the past; in fact the author finds but two references in German literature on the subject, and his own studies lead him to differ with previous investigators who believed in the existence of a definite compound between the two metals. The thermal equilibrium diagram is given in Fig. 1.

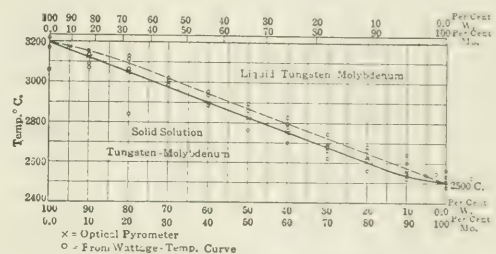


FIG. 1—THERMAL EQUILIBRIUM DIAGRAM

1. By compressing the mixed reduced powders of tungsten and molybdenum into briquets and then heating with an electric current in an atmosphere of hydrogen, alloys of this series were prepared varying in composition from 100 per cent tungsten to 100 per cent molybdenum.

2. The solidus curve for the series was located by means of optical pyrometer temperature measurements and checked by comparing the fusing current with a standardized wattage-temperature curve.

3. The equilibrium diagram for this series shows no critical points, appearing as resistance fluctuations, corresponding to a separation of a new phase. Its construction has been based upon this fact and upon results of microscopical analysis.

4. Curves for hardness, and for equiaxing temperatures, are smoothly convex, being typical of an uninterrupted series of solid solutions (mixed crystals).

5. As a result of thermal and microscopical analysis, the metals tungsten and molybdenum are reported to be completely isomorphous.

6. All alloys of this series are malleable and ductile under proper conditions.

Sulphuric Acid

Roasting and Acid Plants of Braden Copper Co.—In *Teniente Topics* for December, 1915, Mr. JOHN B. WISE publishes a descriptive account of the methods of roasting copper concentrates and producing sulphuric

For the reduction of the tetrachloride to tin the tube *b* must also be used. Tin tetrachloride vapor is admitted through *b* and pure hydrogen through *C*. Zone *C* is again heated to between 600 and 1000 deg. C., zone *B* to 500 to 600 deg. C., and zone *A* to 250 deg. C. The reduction takes place so that at the lower extremity of *b* and zone *B* dichloride is formed, which condenses partly in zone *B* and partly in zone *A*, and descends to *C*. It is there reduced to tin, which flows off through *d*. Any

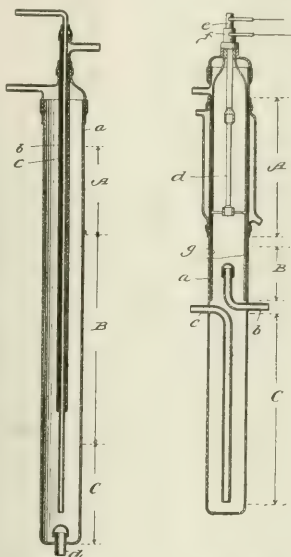
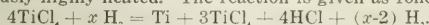


FIG. 1—REDUCTION OF TIN FROM CHLORIDE

dichloride that may have been volatilized, returns through zones *B* and *A* to *C*.

For the reduction of titanium tetrachloride to trichloride the apparatus shown at the right is used. This apparatus is based on the use of process of St. Claire-Deville, consisting of quick chilling of the product previously highly heated. The reaction is given as follows:



In the apparatus titanium tetrachloride is introduced in the form of vapor through tube *b* and pure hydrogen through tube *c*. If it is desired to reduce only to dichloride, zone *C* is kept below 700 deg. C., for reducing down to metallic titanium, a temperature of 800 to 900 deg. C. is used. Zone *B* must be kept at about 500 deg. C., zone *A* is formed by what is known as a Deville tube. A heating device such as a carbon rod is indicated at *d*. Lower leading-in wires are shown at *g*. These also serve as scrapes, for detaching trichloride from the cold wall.

In zone *A* complete conversion into the trichloride takes place. The trichloride drops through *B* to *C*, where it is converted to titanium, titanium chloride, or tetrachloride. Finally, the lower part of *C* will be filled with titanium, while hydrochloride acid and hydrogen escape at the top. The gaseous reducing agent may be a mixture of carbonic oxide and water vapor, instead of hydrogen, and pressure may be used. (1,173,012, Feb. 22, 1916.)

Metallurgical Furnaces

Sulphating Ores Under Pressure.—HENRY B. Hovland, of Duluth, Minn., has patented both laboratory and commercial types of furnaces designed for dry sulphating at superatmospheric pressures. Either type of

furnace involves a container for holding and supporting the material treated; means for agitating the material; an outer casing for withstanding superatmospheric pressure; means for introducing the reacting constituents, such as air and SO_2 , into the apparatus; a bleeder valve, and means for introducing and discharging the material to and from the furnace. (1,164,187, Dec. 14, 1915.)

Annealing Furnace.—An annealing furnace designed to utilize coal, coke, oil or gas producer fuel is patented by CHARLES F. KENWORTHY, of Waterbury, Conn. The furnace consists of an annealing chamber, heated from the outside by allowing the products of combustion to pass through an annular chamber surrounding the annealing chamber. Bright metals can in this manner be annealed free from fire or oxidation and do not require subsequent polishing or cleaning. Below the annealing chamber and in communication with it is a liquid chamber. A number of platforms arranged on vertical supports, which are movable up and down and sideways, carry the work to be annealed. A hydraulic piston arrangement moves these platforms from the liquid up into the annealing chamber and then back into the liquid. An automatic valve at the top of the annealing chamber releases suction or pressure and prevents liquid from being drawn up into the annealing chamber. The gas producer may be placed adjacent to the annealing furnace and directly connected to it. Pyrometer thermocouples are joined to the vertical supports at each platform. (1,169,494, Jan. 25, 1916.)

Calcining Furnace.—A furnace designed for heating finely divided or granular carbon is shown in sectional elevation in Fig. 2, being the patented invention of WILLIAM R. CLYMER of Cleveland, Ohio. The calcining chamber 2 extends centrally from top to bottom of the furnace, and is fed with the material to be calcined from a hopper 3. The treated product is removed by screw conveyor 5 and discharged at 7. Surrounding the heating chamber is a tortuous passage 8 communicating with passage 9 which, in turn, is connected with an air supply. Another tortuous passageway 10 is in communication with a fan 12, the latter also being in connection with the calcining chamber by means of duct 13. Passages 8 and 10 merge into a combustion chamber 14 which communicates with passage 15 which ends in a stack or flue 16. The gases given off from the calcining mass in the heating chamber are drawn by the fan and delivered into passage 10 and thence in combustion chamber 14, where they are mingled with air entering through 8. This produces the heat necessary to treat the mass in the chamber 2. As the products of combustion pass through 15 to a point of discharge they give up heat to the material in the upper part of the chamber. As the charge descends in the shaft it will give up heat to the air in passage 8 and thus preheat it for combustion with gas in 14. (1,147,706, July 27, 1915.)

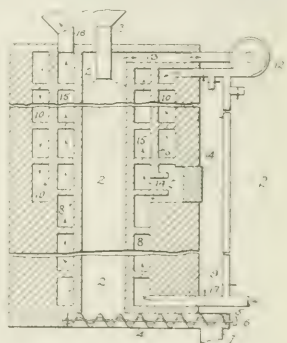


FIG. 2—CALCINING FURNACE

Sintering or Chloridizing Furnace.—A furnace designed to treat ore by roasting in a continuous oper-

New Barometric Condenser

The Ingersoll-Rand Company, 11 Broadway, New York City, is now offering to the trade complete steam condensing plants for all service conditions. This equipment includes the Beyer barometric condenser, for which the company has secured the patent rights, Imperial duplex and Ingersoll-Rogler straight-line, reciprocating, dry vacuum pumps and, where required, Cameron simplex and centrifugal pumps.

The Beyer barometric condenser is of the counter-current type, in which air and cooling water flow in opposite directions. The steam inlet is at the bottom of the condensing vessel, the water inlet above and the air removal opening at the top. The sheets of cooling water overflowing the pool at the inlet point meet the entering steam. The two are brought into intimate contact by conical baffle plates assisting the water to absorb to its full capacity the latent heat of the steam. The non-condensable air liberated in the condensing action rises through the falling water to the removal point at the top, being cooled to practically the temperature of the incoming water. It is also to be noted that ample opportunity is given for the removal of the air content of the water before it mixes with the steam. This not only facilitates the mixing process, but permits the removal of air and vapor at a comparatively low temperature, which is a distinct advantage as the reduced volume saves in vacuum pumpage horse power.

The steam inlet is of large diameter to secure low velocity and is hooded in such a way as to discharge the steam into the center of the condensing vessel. The air removal opening is also of ample area and is protected by a self-draining baffle and trap. This, it is said, positively prevents water being carried over into the vacuum pump.

The hot waste water is discharged through the self-draining tail pipe. This pipe straddles the hot well and rigidly supports the condenser.

The Imperial and Ingersoll-Rogler Vacuum Pumps

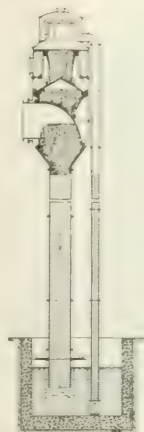


FIG. 2—SECTION OF BEYER BAROMETRIC CONDENSER

condensing unit serving a number of prime movers.

are of the manufacturers' standard type. They are high-speed reciprocating machines, wholly enclosed, automatically lubricated and are claimed to effect a floor space saving approximating 50 per cent over the more common slower speed vacuum pumps.

When a water pump is required to elevate cooling water to the condenser head Cameron pumps are provided. These may be either reciprocating or centrifugal, as desired. The Ingersoll-Rand Company, however, emphasizes the fact that, where the level of the cold well is of sufficient height above the hot well, the condenser will lift its own cooling water, dispensing entirely with a water pump.

The vacuum and water pumps, being independently operated, can be regulated to suit varying water temperatures and conditions, and this plant, in addition to its efficiency in general service, is admirably adapted for duty as a central condensing unit serving a number of prime movers.

Disc Crushers in Use at the Intermediate Stage

The Symons disc crushers, made by Messrs. Chalmers & Williams of Chicago, Ill., have proven highly economical as intermediate crushers. In most large plants crushing is done in several stages, the first break being made in heavy jaw or gyratory crushers, and the second break was formerly done by smaller jaw or gyratory crushers, or crushing rolls. It is in this second or intermediate stage of crushing where the disc crushers are used.

One of the features is that both discs turn in the same direction at the same speed so that there is practically no abrasion or grinding action between the two discs. The material fed through the spout is immediately distributed by centrifugal force and that portion sufficiently fine is thrown out through the opening between the discs against wearing plates in the hood and discharged.

The range of reduction is large, the product uniform, and the capacity per horsepower very high. The cost of operation, of course, depends upon the material being handled and local conditions. The cost of repairs ranges from under 1.5 cent to about $1\frac{1}{2}$ cent, the latter being high. In one plant crushing hard gravel the total cost for reducing material from $3\frac{1}{2}$ in. to $3\frac{3}{4}$ in., including every item of expense connected with operation, was 97 cents per 100 tons.

Another crusher made by the same company is the Symons fine-reduction disc crusher, which is only made in one size. This machine was developed primarily for receiving a feed $21\frac{1}{2}$ in. and finer, and crushing down to $\frac{1}{4}$ in. and finer. When used in this way the efficiency is very high and the cost for operation extremely low. It may be operated either wet or dry and the product is very uniform. The New Cornelia Copper Co. of Arizona, recently ordered thirteen of these machines for crushing dry. There will be three units with three crushers in each unit and a fourth unit to be held in reserve. The three units of nine crushers will handle material discharged from gyratory crushers set to $3\frac{1}{2}$ in. and deliver a product all practically $\frac{1}{4}$ in. and finer.

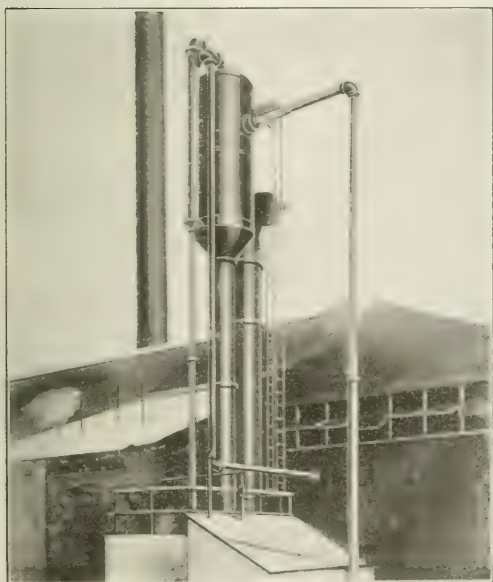
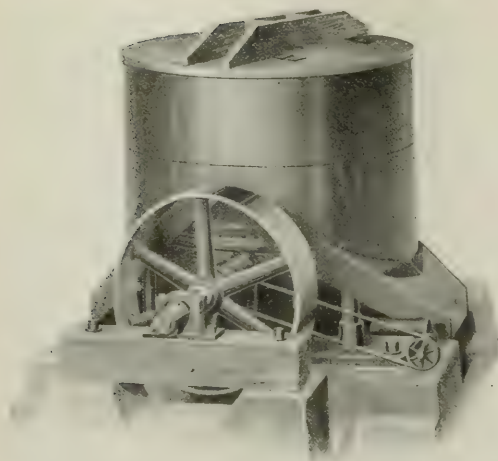


FIG. 1—OUTSIDE VIEW OF BEYER BAROMETRIC CONDENSER



SYMONS FINE REDUCTION DISC CRUSHER

These nine crushers will handle 4,000 tons in 16 hours and based upon tests extending over a long period, will not use over 360 hp.

As a result of extensive tests made upon these machines it has been found that by changing the upper disc slightly and the feed opening, material can be handled up to 4 in. ring and reduced at once to $\frac{3}{8}$ in., $\frac{1}{2}$ in. or $\frac{3}{4}$ in. When so operated the capacity is practically all that can be fed into the machine and may be 50 tons per hour and up; the power in no case should exceed 60 hp. and usually would not be over 40 hp.

Personal

Mr. F. L. Craddock has been appointed manager of the New York office of the Pfaudler Company, Rochester, N. Y., and Mr. R. B. Kilmer has been appointed manager of the Chicago office.

Mr. George W. Fraser, formerly superintendent of the smelting department of the Arizona Copper Co. at Clifton, Ariz., has been appointed superintendent of smelting at the plant of the American Copper Syndicate, Ltd., at Aroa, Venezuela. He left for his new post July 6.

Mr. Robert C. Gemmel, general manager of the Utah Copper Co., has been elected a director of the company. Mr. John M. Hayes, assistant cashier at Salt Lake City, has been appointed treasurer.

Mr. S. S. Jones has resigned his position as superintendent for the Tom Reed Gold Mining Co. in the Oatman district, Arizona. The entire management of the company changed on June 1 and practically all of the new staff are former employees of the Gold Road Co.

Mr. Bernard MacDonald has moved his office from Los Angeles to 715 Mills Building, El Paso, Texas, where he will continue his professional work. At present he is collaborating with the engineering staff of the Alvarado Mining & Milling Co. in designs for increasing the capacity of that company's mill at Paral, Chihuahua, from 400 to 600 tons per day. The machinery has been ordered and will be installed as soon as peace is established in Mexico.

Mr. Richard K. Meade, consulting chemical engineer and cement expert of Baltimore, Md., was elected to membership in the Phi Beta Kappa Society at the recent commencement of the University of Virginia, in

recognition of his attainments in the field of chemical engineering and especially hydraulic cements. As the University of Virginia confers no honorary degrees election to this society is the highest gift the University may confer on its distinguished alumni.

Mr. Guy C. Riddell, formerly smelter superintendent for the A. S. & R. Co., at East Helena, Mont., has been retained to investigate the lead smelting practice of the same company.

Mr. Gilbert Rigg, formerly in charge of research work for the New Jersey Zinc Co., has been appointed to a consulting position in the zinc smelting department of the Broken Hill Associated Smelters Proprietary Co., Ltd., Port Pirie, South Australia.

Mr. O. C. Schaefer, formerly superintendent of the National Radium Institute of Denver, has accepted an appointment as superintendent with the Chemical Products Co. of Denver, manufacturers of molybdenum, vanadium and barium products.

Mr. E. Bryant Thornhill has accepted a position with the Metals Recovery Co., Ltd., Cobalt, Ontario, Canada.

Mr. Carl J. Trauerman, mining engineer and metallurgist, has resigned the position of mill superintendent of the August Mining Co., Landusky, Mont., and is inspecting the properties of the Beaver Creek Mines Co. of Zortman, Mont. After examining mines in the Kendall, Elliston and York districts of Montana he will return to his headquarters at Butte, Mont.

Prof. A. L. Van Hecke of the University of Louvain, Belgium, is in this country studying the latest developments in steel and iron. He attended the recent meeting of the American Society for Testing Materials at Atlantic City.

Mr. A. Van Zwaluwenburg is now chemist for the Nipissing Mines, Ltd., Cobalt, Ontario, having given up his position with Walter Harvey Weed in preparation of the Mines Handbook.

A number of changes have recently taken place in the U. S. Bureau of Mines. Mr. C. A. Wright, who has been in the Joplin district for some time, has been transferred to Salt Lake City. From the Denver office of the bureau, Mr. Alan Leighton has gone to the Goodrich Rubber Co., Akron, O.; Mr. J. C. Morgan has been transferred to Salt Lake City; Mr. H. A. Doerner has been engaged by the Chemical Products Co. of Denver, and Mr. C. F. Whittemore has accepted a place with the Schlesinger Radium Co. of Denver.

Mr. R. J. Weitlaner, formerly with the Midvale Steel Company, is now in charge of a Heroult electric steel furnace at the plant of the Hess Steel Corporation in Baltimore, Md.

Obituary

Lucius L. Wittich, mining news editor of the Joplin (Mo.) News Herald, died at Joplin on June 25, 1916. For many years his name had been prominently identified with the lead and zinc industry of Missouri and particularly of the Joplin district, through his contributions to the popular and technical press and his skill in gathering and presenting statistics on lead and zinc production. He had the latter feature well organized and the results were considered reliable and representative. As a leader in local mining news circles, his loss is keenly felt and his place difficult to fill.

Alvin R. Kenner, graduate mining engineer from the Colorado School of Mines in 1907, was found drowned in a lake near Grass Valley, Cal., on July 5. Mr. Kenner was superintendent of the Rio Plata Min-

ing Co. in Mexico and visiting in the States at the time of his death. He was an occasional contributor to the technical press and was favorably known among his engineering colleagues.

Industrial Notes

Fluorspar in 1915.—The year 1915 was a record year in the fluorspar industry in the United States, according to a Geological Survey Report by E. F. Buchard. The output of 136,941 short tons exceeded that of the next highest year 1912 by more than 20,000 tons, or nearly 18 per cent. The general average price of domestic fluorspar has declined steadily in the last four years, largely as a result of improvements in methods of milling and handling large quantities in the Illinois-Kentucky District, and this price was lower in 1915 than at any time in the last ten years.

Standard Methods of Gas Testing.—The second edition of this work has just been published by the Bureau of Standards as Circular No. 48. The first edition was compiled to fill the need for a publication which could be accepted as a standard guide to the methods of testing gas used for illuminating and heating purposes. The second edition is a revision of the first, embodying new suggestions and the results of work carried out by the Bureau. The different sections deal with the following subjects: location and general equipment of laboratory, measurement of gas, measurement of heating values, candlepower determination, determination of impurities, pressure records, meter testing, specific gravity, dew point and atmospheric humidity.

Rennerfelt Electric Furnaces.—Hamilton & Hansell, 17 Battery Place, New York, announce the sale of the following Rennerfelt furnaces:

One 2 3-ton, 150-kw. to the Tungsten Products Co., Boulder, Col., for making ferrotungsten. Two further furnaces, one 3 tons, one 6 tons, for making ferrotungsten. Not at liberty to name the party at this time, although the furnaces are for domestic use. One 3 $\frac{1}{2}$ -ton, 225-kw. for making steel to the Samson Iron Works, Stockton, Cal. One 1 3-ton, 100-kw. for bronze to the Titanium Alloy Mfg. Co., Niagara Falls, N. Y. One 1 3-ton, 100-kw. for bronze to the Gerline Brass Foundry Co., Kalamazoo, Mich.

In addition to this, three additional furnaces were sold in Europe, making sixty-four Rennerfelt furnaces contracted for now in the world, fourteen of which are for the United States.

Dividends of German Companies.—The annual statements of the most prominent German companies for 1915 show that the number of companies announcing no dividends for the year was relatively small compared with the total number reviewed, according to a U. S. Consular report. It also appears that an excessive decrease in dividends was only declared in a minority of cases, and only by undertakings that were either insufficiently financed originally or were manufacturing articles of luxury and products intended for export. The porcelain and glass industries as well as the potash works, which generally exported more than half of their entire production, naturally had to declare greatly decreased dividends because the loss of exports could not be replaced in other ways. The cement factories, which were not in the best of condition in times of peace, have suffered greatly.

In general, decreased dividends were reported by the industrial lines not actively engaged in the manu-

facture of war supplies. The limitation of production in many industries has not only been caused by a decreased demand but by a lack of producing facilities. The industrial lines in which relatively high dividends were announced are principally mill products, chemicals, paper, coal, iron, steel and textile industries.

The D'Olier Centrifugal Pump & Machinery Co., Philadelphia, Pa., describes in the June issue of its bulletin wood screw type pumps for irrigation and drainage service, centrifugal pumps and multi-stage pumps. Descriptions of the D'Olier-Weston centrifugal pumps are also included.

Large Increase in Coke Production.—The coke production in the United States in 1915 was 41,581,150 short tons, an increase of 20 per cent over the 1914 production. Of this total, 34 per cent was by-product coke and the balance was made in bee-hive ovens. The increase over 1914 in the output of by-product coke was 25 per cent, and in bee-hive coke 18 per cent. The quantity of by-product coke made was the greatest yet recorded.

Lignite in South Dakota.—In Perkins and Harding Counties in South Dakota, it is estimated by United States Geological Survey that there are 1,000,000,000 tons of lignite. The estimate is given in Bulletin 627, just published. At present this lignite is mined for local domestic use and as fuel for steam plow equipments. Experiments made by the United States Geological Survey and later at the Bureau of Mines and the North Dakota School of Mines have proved that this lignite, on briquetting, makes a very superior fuel. When burned without briquetting in a producer-gas engine it is more efficient than the best coal when burned under boilers.

Dyestuff Industry Developing in Japan.—According to a representative of the Mitsui Mining Co., as published in Commerce Reports, all the by-products of the Government Iron Works, the Mitsui Mining Co., the Mitsu Bishi Co., the Tokyo Gas Co., the Osaka Gas Co. and other factories are being fully used. The supply of coal tar now exceeds 60,000 tons. In its distillation many big commercial interests are engaged. The foremost of these is the Nippon Dyestuff Co., which has a capital of 8,000,000 yen (\$3,988,000). It profits from Government protection under the law for the encouragement of chemical and dyestuff industries, although the concern is still far from actually being in operation. Gas companies in Osaka and Tokyo have also taken up the manufacture as a subsidiary branch, as they have a good supply of coal tar at their disposal. Aniline salt and induline are already marketed by the Tokyo Gas Co. The Mitsui Mining Co. has succeeded in producing a variety of dyes from the coal tar produced by its works at Miike. A month hence the company hopes to extend the list of its products so as to include additional derivatives of benzol, carboic acid, salicylic acid and picric acid. There are also many minor enterprises engaged in this branch, including the Osaka Chemical Industry Co. and the Kobe Seikojo. These produce several artificial dyestuffs and contribute much to the rapid development of the important new industry in this country. There are still many difficulties to be overcome. In the first place the scarcity of auxiliary materials hampers the efforts of manufacturers. Sulphuric acid is obtainable, but there is said to be no stock of oleum in this country. Caustic soda and soda ash are also scarce. Unless these materials can be more freely supplied the development of the dyestuff industry will be seriously retarded. In the second place dye-

stuff producers are confronted with a grave problem in finding a market for by-products. The local demand is small. The success of dyestuff enterprises depends largely on the advantageous disposal of these by-products. Lastly, there is a pronounced technical difficulty to be overcome. As the enterprises are developed the equipment necessarily becomes more and more elaborate, and experts' difficulties in handling the problems are all the more enhanced.

Digest of Electrochemical U. S. Patents

PRIOR TO 1903

Arranged according to subject-matter and in chronological order.

Compiled by Byrnes, Townsend & Brickenstein, Patent Lawyers, National Union Building, Washington, D. C.

Aqueous Bath Apparatus

704,401, July 8, 1902, Julius Taluan of Philadelphia, Pa., assignor of one-half to Henry W. Scattergood of Philadelphia, Pa.

Relates to a method of framing glass suitable for making stained glass windows, and refers to an earlier application filed in 1895, serial number 572,318. In the present invention, a conducting support such as sheet lead, has placed upon it pieces of wax or other non-conducting adhesive which are of the same shape as the glass pieces, but are slightly smaller, so as to leave an edge around the under side of the glass pieces which are supported upon the smaller wax pieces. Spaces are also left between the several glass pieces. The assembled mass is now placed in the depositing vat, and metal deposited upon the lead sheet between the pieces of glass, and continued until it overlaps at the upper edges thereof, the deposit upon the lower side overlapping the bottom edges on account of the wax sheets having been cut smaller and providing the free edge above referred to. The united glass pieces are then suitably framed.

709,513, Sept. 23, 1902, Henry W. Scattergood of Philadelphia, Pa.

Relates to a method of framing glass or other materials, for making stained glass windows, mosaics, and the like, and consists in securing the glass pieces to a piece of tissue-paper, leaving spaces between the glass pieces, filling the spaces with a starch composition or the like which may be subsequently removed by washing, inclosing the entire object in a frame and filling the frame with sand or other easily removable packing and securing the sand in the frame by a removable cover. The frame with its contents is now inverted, and the tissue-paper removed; a coating of graphite or bronze powder is applied to the entire back of the glass pieces and starch filling, and conductors connected thereto. A second frame is then attached to the first and filled with wax. The entire mass is now inverted, the sand and starch filling removed, and then immersed in an electrolytic tank, deposition of metal being effected upon the graphite in the spaces between the glass pieces to the desired thickness so as to securely hold the glass. The spaces may be partly filled with metal filings if desired to reduce the quantity of electrodeposition required. The structure is now inverted, the wax backing and graphite removed, and the deposition of metal continued upon the metal seams between the pieces of glass until they are securely held on both sides of the assembled window.

Aqueous Bath, Cathodes Metalizing

7,821, Dec. 10, 1850, George Mathiot of Washington, D. C.

Relates to coating a cathode with a deposit which facilitates subsequent separation of an electrodeposited coating. For engraved metallic plates, etc., an electrodeplate of silver is first deposited, this silver deposit is chemically cleaned, and is then treated with an alcoholic solution of iodine which is then quickly drained off, and the plate exposed to the light for one or more hours, when it acquires a "leaden" appearance. It is now immersed in the electrolyte and the deposit proceeded with by the usual methods. When completed the deposit is readily separated from the cathode plate. For large cathodes, of 10 sq. ft. or more surface, one grain of iodine is dissolved in 20,000 grains of alcohol; for smaller plates, stronger solutions may be used.

23,633, April 12, 1859, John W. Wilcox of West Roxbury, Mass.

Relates to making rolls for printing, paper-making, etc., and consists in covering an iron or other metal roll with a strip of copper wound as a helix, the joints between the turns of the strip soldered, and the strip itself may be soldered throughout to the roll. The completely covered roll is then turned or ground perfectly true, and electroplated with a thick coat of copper. It is then ready for use.

Book Reviews

The Molecular Volumes of Liquid Chemical Compounds. By Gervaise Le Bas, B. Sc. Octavo (15 x 22 cm.), 272 pages, 9 illustrations; price, \$2.25. London and New York: Longmans, Green & Co.

This treatise is for advanced students of chemistry, and is intended to elaborate the theory of molecular volumes of Kopp in the light of modern researches. The author retains Kopp's conception of molecular and atomic volumes and of the additive principle in this connection, but adds to these several modifications, such as using several atomic volumes for oxygen and nitrogen in different types of compounds. By also revising the values of the atomic volumes of carbon and hydrogen, used by Kopp, many constitutive properties of compounds are thus revealed and a fairly consistent theory of molecular structure built up. The whole is a report of progress, worth careful study by all interested in physical chemistry, but the conclusions lack finality—which holds out good promise of still further progress.

Steel and Its Heat Treatment. By Denison K. Bullens, Consulting Metallurgist. Octavo (14 x 22 cm.), 431 pages, 223 illustrations; price, \$3.75. New York: John Wiley & Sons, Inc.; London: Chapman & Hall, Ltd.

This is a good treatise on annealing, hardening, tempering, toughening, and case-hardening of carbon, nickel, chromium, chromium-nickel, vanadium, manganese, tungsten and other alloy steels, together with chapters on pyrometers, critical range determinations, and mechanical testing. We find it a very readable and interesting book, with a mass of well-arranged and useful information. It is, however, far from complete, and may disappoint because of its omissions, such as the special treatment of high-tungsten steel for magnets and high-speed tools, the meager description of heating baths and of electric heating furnaces for automatic heat treatment. We protest, also, against "chrome" being generally used instead of "chromium" throughout the book—a point on which the printed treatise should rectify current workshop carelessness. With some such additions and corrections as above mentioned the book could be made considerably better.

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Why People Should Interest Themselves in Electrochemistry

It is remarkable how the conception of the scope of chemistry has recently grown in the general public's mind, after chemistry had been synonymous with drugstores so long to so many people. Everyone is now acquainted with at least one other field of chemical endeavor—dyestuffs—and thus chemistry has made a clear advance of 100 per cent in popular estimation. Among technical men, however, it is electrochemistry that is now attracting greatest attention. Of course, as long as Faraday's law has been taught in schools, those who had to learn it knew of electrochemistry. But for many its scope was restricted to batteries and plating. Naturally electrical engineers knew better, as they had to buy their copper from the electrolytic copper refinery and the generating capacity of an electrolytic refinery is sufficiently impressive to gain the respect of any engineer. No wonder that many a man who had been interested in lighting and traction systems is now attracted by electrochemistry which has no such sources of trouble as a public service commission. Finally the power famine at Niagara—deplorable as it is—has had at least one good result—that attention has been attracted to the nation-wide economic importance of the Niagara electrochemical industries. (Compare the report on page 115 of this issue.) And the doubling in the number of American electric steel refinery furnaces during the last year is but another illustration of the same story.

There are two essential reasons why American engineers should interest themselves in the American electrochemical industries. First, because they are of fundamental economic importance for the whole country. Second, because they are thoroughly American in origin and thus a source of profoundest pride for the nation. We hope that many engineers, and especially electrical engineers, will take advantage of the meeting to be held by the American Electrochemical Society in New York in September, to make themselves acquainted with American electrochemists. There is no more congenial crowd to mix with.

University and Industry

During last winter the New York Section of the American Chemical Society held a series of meetings for the purpose of discussing the various phases of the interrelation between science and industry and promoting a heartier co-operation between the two. All of these meetings, which were fully reported in this paper, were very interesting and very suggestive. But, after all, it is human, all too human, to listen

attentively and approvingly to the preacher's admonition on festival occasion and forget promptly the good intentions in the pressing every-day duties of the morning after.

In this issue we record a real deed. The article by Prof. W. H. Walker on the new chemical engineering course of the new Massachusetts Institute of Technology tells how a splendid idea of most direct co-operation between university and industry is being transformed into reality with a boldness of conception that is unique in the history of chemical education. It is a grand pioneer experiment in education. We heartily wish that it be successful in such overwhelmingly convincing style that in the end it will be remembered but as the pioneer experiment and the forerunner of many others.

The Steel Production Statistics

There have lately appeared the statistics of production in steel ingots, steel castings, and rolled steel in 1915. The figures are studied with particular interest on account of the changed character of demand last year, whereby a large tonnage of steel was rolled for shell making, with unusually heavy discards, and one naturally looks to see whether the statistics indicate the production and consumption of an unusually large tonnage of scrap in the open-hearth furnaces.

One interesting comparison to be made is between the tonnage of basic pig iron and the tonnage of basic open-hearth ingots and castings. The production statistics, with the percentage of pig iron to steel, are given below, also the production of duplex steel for the year for which such statistics were gathered:

	Steel, Gross Tons	Pig Iron, Tons	Proportion, Pig to Steel	Duplex Steel, Gross Tons
1896	776,266	306,406	39.3	
1897	1,056,043	556,444	52.7	
1898	1,599,412	785,441	50.1	
1899	2,080,426	985,023	47.4	
1900	2,545,091	1,072,376	42.1	
1901	3,618,993	1,448,850	40.0	
1902	4,496,533	2,038,590	545.2	
1903	6,753,126	2,040,726	30.2	
1904	5,106,367	2,182,104	42.7	
1905	7,815,728	3,195,179	52.5	
1906	9,658,760	5,018,674	52.0	
1907	10,579,315	5,375,219	50.4	
1908	7,140,425	3,000,114	42.1	
1909	13,417,472	5,250,225	61.9	
1910	15,292,329	9,081,608	79.5	
1911	14,685,932	8,520,020	58.0	
1912	19,641,502	11,417,336	58.1	
1913	20,344,626	12,536,693	61.6	
1914	16,271,129	9,670,687	59.4	
1915	22,368,172	13,093,214	58.7	1,781,491

Thus the largest proportion of scrap used appears to have been in 1901. For a number of years, ability to hold down the proportion of pig iron was due, in part at least, to the diversion of Bessemer scrap from the Bessemer converter to the basic open-hearth furnace. In 1906 there occurred the maximum production of Bessemer steel, its production having decreased since then, while the production of basic open-hearth steel has more than doubled. The percentages given in the above table are not, of course, identical with the average percentage of pig iron charged to the furnaces, but the annual fluctuations are a trustworthy index. The maximum proportions of pig iron fell in 1909 and 1913. The increase in the use of direct metal has made it convenient to use larger proportions of pig iron. In

1915 no less than 73.7 per cent. of all the basic pig iron produced was delivered molten, while 13.3 per cent. of the production was made for sale, and was, therefore, necessarily cast. It is to be observed that the amount of duplex steel produced has really not been large, and this process has, therefore, not thus far decreased to any extent the proportion of scrap used in the basic open-hearth furnaces as a whole. Duplex steel is, of course, reported as part of the total of basic open hearth produced.

The quantity of scrap used in the basic open-hearth furnace in 1915 was only slightly less than in immediately preceding years. There is no doubt that there were larger supplies on account of the liberal cropping practiced on several million tons of steel made in the year. The effect of the extra scrap production appears to have been seen chiefly in an influence operating to prevent the scrap market from advancing as sharply as did the unfinished and finished steel markets.

The figures cited above are suggestive as to the consumption of scrap. As to the production of scrap, there are other figures that can be studied, by making comparison between the production of steel ingots and of finished rolled steel. The statistics of rolled steel are gathered in such form that comparisons from year to year can readily be made. "Rolled steel" includes, in general, material weighed in the form in which it leaves the hot rolls for the last time, but, of course, after shearing. Thus, the statistics refer to sheets and black plates, rather than to sheet bars; to skelp, rather than to welded pipe; and rods, rather than billets or wire. Rolled forging billets and all billets, etc., for export, are included, as otherwise the material would be lost to the statistics. The comparison is as follows:

	Steel Ingots, Gross Tons	Rolled Steel, Gross Tons	Proportion of Rolled Steel
1912	30,284,682	23,019,259	76.01
1913	30,280,130	23,112,986	76.34
1914	22,819,784	17,202,420	75.38
1915	31,284,212	23,098,091	73.83

There is scale produced, and in comparing different years there may be slight divergences due to there being larger proportions of light material rolled in some years than in others. Generally speaking, however, there was evidently much larger cropping of ingots and billets in 1915 than in any other year. It is a fact, moreover, that some mills produced ingots late in 1914 for stock, the demand being very light, such steel contributing to the ingot statistics for 1914 but to the finished-steel statistics for 1915; and thus the rolled steel in 1915 may have been less than normal by approximately 3 per cent. of the ingot production.

The fact that the statistics indicate the production of scrap, or billet discards, rather than its consumption, may be explained, in part at least, by the material accumulating at works.

Bleeding Kansas

Kansas is always in the throes of something or other. We hark back to the time when, to all appearances, single-handed and alone, Kansas was fighting the demon rum, with only the encouragement of old Uncle Jehoshaphat Maine, who shouted his hurrahs—between drinks.

Then came Populism and Sockless Jerry Simpson, the while the Kansas farmers ploughed deeper and deeper and bethought themselves of new notions. The trouble with Kansas is that she is never satisfied, and as time rolls on, and as some of us grow old and begin to wish that she would settle down and become conservative and sensible, like other folk, Kansas doesn't settle down. It is a nervous and unbiddable community. There is abundant tradition, all over the world, that if anybody has a new idea he should be snubbed and told to go back to that station in life to which, in the minds of conservative persons, it hath pleased God to call him. Such a station of life, in the minds of the truly conservative, is nearly always in the back row.

But Kansas is not conservative. It has no respect for tradition or established forms or justification by cult. It is a nervous, restless place, and is not to be recommended to elderly gentlemen of a gouty or rheumatic tendency, with fixed habits of mind.

At the Kansas State University at Lawrence, as soon as the late Robert Kennedy Duncan began to display chemistry so that it became attractive to the man on the street, they called him to their chair of industrial chemistry. Then when that man o' dreams conceived the idea of establishing industrial fellowships with the view to applying chemistry to daily life and the affairs of men, they took it up immediately, and it is still going at full tilt. Out of this the Mellon Institute of the Pittsburgh University was born, and in it is indicated one real link between the universities and industry. No one who has the development and spread of chemistry at heart can visit the Mellon Institute and observe their methods of attack in industrial research, without becoming inspired with the belief that that is a real thing. The idea comes from Kansas.

The students of chemistry and metallurgy at Lawrence have just issued the first number of an annual paper which they call *The Kansan Chemallurgist*. It has twenty-four pages, and it is utterly devoid of sporting news. That is another innovation! Who ever heard of a college paper without even a baseball or a football score? There is no mention of the hockey team or the glee club or of the most popular man of the Class of '16. This seems unusual enough to be all wrong—to the conservative mind. And yet that magazine is full of readable stuff. It begins with what might be called an horn solo about Kansas and her industries. We learn that in 1914 the value of products manufactured in that State was \$328,936,964. The two leading industries are slaughtering and meat packing, and flour milling; and we might mention right here that there is a crying need for chemical research in regard to flour that has not yet been accomplished either in Kansas or Minnesota or Buda-Pesth or anywhere else as yet. Then come zinc smelting and refining along with the production of sulphuric acid, cement, brick and tile, glass, leather goods, salt, paint and varnish, pottery, dairy products, and a lot more. The zinc production in 1915 was over \$40,000,000 worth—but that may be high-water mark. The cement industry has developed into the millions in output; there are twenty-three glass works, and, alas! it

grieves us to repeat it: "Kansas is not to be left out of the coke industry and can *boast* of sixty-seven bee-hive ovens in the southeastern part of the State." (The italics are ours.) Let us hope that Kansas will soon cease to boast over bee-hive coke ovens.

There is an article by L. S. Bushnell, who urges young chemical engineers to get into the works rather than into the laboratory to the end that they may learn to produce, and Dr. Charles H. Herty comes along with the advice not to jump into jobs too soon at the expense of adequate preparation. But this is said with such grace and *savoir faire* that it sounds less like advice than like a good thing to know. The university has a department of State Chemical Research under Prof. W. A. Whitaker, and this is conducting investigations in the following subjects: prevention of zinc mineral wastes by means of flotation, salt deposits of the State combined with a potash quest, survey of natural gases, removal of iron and softening of municipal water supplies, disposal of municipal sewage and studies of the yucca plant and of sunflower oil.

We learn also that there is a K. U. Chemical Club which meets Wednesdays in which the following papers have been read by members of the faculty during the current year: standardization of chemicals and drugs; effect of radio-active substances on plant growth; ductless glands; micro-metallography of ores in the Comstock Lode; notes on salicylic acid and its allies; chemistry 3000 years ago, antaphylaxis and antaphylactic reactions, enzymes and enzyme action, electric culture, putting your uncle to work, and preparation and use of hydrogen during the European war. Then, as though resolved to be in the fashion, they have a Society of Chemical Engineers with papers by research students and men of affairs in the industries. We find that the chemical faculty of the University numbers twenty-two and the record of the alumni indicates that they stick to chemistry. Here and there one falls from grace, as in the case of a member of the class of 1892 who is now literary editor of one of the leading magazines published in New York. Six are fellows of the Mellon Institute.

The purpose of these remarks is criticism: criticism of those young men of Kansas for their own good. We have mentioned Sockless Jerry Simpson with what was designed for scorn, and we do not approve of the name "Chemallurgist." We think the English language has enough burdens to bear without inventing new ones for it. But when we have said this we can find no more fuel for our critical fire. It seems as if those fellows were live wires. We shall put their magazines away in our files and expect to read their names again. Somebody out there seems to know how to teach and to inspire young men, and the material appears to be of good quality.

Of course, Kansas will continue to bleed. She must bleed in order, to quote Scripture, "that the prophecy may be fulfilled"; that we may continue to use the expression to which our tongues have accustomed themselves. But it doesn't seem to do Kansas any harm. She appears to be taking care of herself. We should like to see some other States do a little similar bleeding.

Readers' Views and Comments

The Dyestuff Tariff

To the Editor of Metallurgical & Chemical Engineering

SIR:—In reading over the copy of the "Dye Stuff Tariff Before Congress," reported on page 65 of the July 15 issue, I notice that several articles such as hydroquinone, pyrocatechin and phenolphthalein and possibly some others, have been omitted in the proposed bill, and I have wondered whether this omission was intentional or accidental. The necessity for protecting these articles is not by any means imaginary, since some of them have been made the subject of dumping by the producers abroad, much to the detriment of our manufacturers. I regard the injection into tariff provisions of a really efficient anti-dumping clause as of even more importance to our industries than a prohibitive tariff rate.

That very unfair practices have been indulged in by importers is known to all of us in the profession, and the law makers need careful instruction if this is to be really avoided in the future.

When I was running for Congress two years ago in the 26th district, I had a letter from the president of one of our largest chemical companies wishing me success. For said he, "We have not a single person in the House of Representatives to whom we can go and talk intelligently with the expectation of being understood."

Easton, Pa.

EDWARD HART.

The Ball Mill for Regrinding

To the Editor of Metallurgical & Chemical Engineering

SIR:—The writer was very much interested in reading the article on "Concentration and Flotation of Lead Ores in Southeastern Missouri," in your issue of July 15, 1916, since he has just returned from an extensive trip through this district.

Under the heading of "Crushing and Grinding" a statement is made to the effect that "the first introduction of the modern ball mill for regrinding is being made at the Rivermines Mill of the St. Joseph Co., where an 8-ft. dia. Marcy mill operated by a 200-hp. motor is being placed." This statement is not quite correct, since a 6-ft. Hardinge ball mill has been in operation at the plant of the Desloge Company since the early part of April, 1916, for the regrinding of their jig middlings. Two further Hardinge ball mills are also being installed in this district at the present time, one, an 8-ft. dia. machine at the plant of the Federal Lead Co. at Flat River, driven by a 125-hp. motor and the other a 6-ft. dia. machine in the Bonne Terre plant of the St. Joseph Lead Co. These machines are all intended to regrind minus 9 mm. and plus 2 mm. jig middlings for table concentration in place of the rolls which have previously been employed for this work.

The Hardinge ball mill at the plant of the Desloge Co. was the first introduction of a modern ball mill of either the conical or cylindrical type in this district and antedated the introduction of the cylindrical mill at the Rivermines mill by some three months.

R. B. T. KILIANI.

Hardinge Chemical Mill Co.,
New York City.

By-Product Coal Ammonia as a Domestic Nitrate Source

To the Editor of Metallurgical & Chemical Engineering

SIR:—The present unusual interest which is being given to the development of those industries and proc-

esses which are necessary for the production of war munitions and as a means for preparedness has a tendency to cause certain assumptions to become fixed in the public mind as basic facts and which form the starting point for all discussions. This tendency may cause us at this time to take action which will restrict the development of certain of our natural resources rather than assist them. For instance, certain of our scientific authorities are at this moment making the radical assumption that the basis of an independent source of nitric acid lies solely and only in the development of cheap water power.

The object of this short discussion is to call attention primarily to the fact that we have at hand the potential elements of the cheapest electric power and an almost unlimited supply of raw material for nitric acid, and that these elements do not depend upon or concern themselves in the slightest way with the development of water power.

It might be well to consider for a moment the possible sources of the nitric acid supply which our military authorities consider to be the essential element in the manufacture of explosives in case the seas were not open to our commerce.

Outside of the well-known Chile nitrate beds on which we depend at present, there exists three possible sources of nitric acid supply:

First—The electric arc oxidation of atmospheric nitrogen to the nitric oxides and the conversion of these to nitric acid direct. (The Birkeland Eyde and Pauling processes.)

Second—The hydration of atmospheric nitrogen to ammonia in the electric furnace or catalytic process and the subsequent oxidation of the ammonia to nitric acid (The Haber process and more indirectly the cyanamid process).

Third—The oxidation of ammonia formed directly in the coking or gasification of our bituminous fuels to nitric acid by the catalytic process. (The Ostwald process is also the final step under Class 2.)

All these three sources are being utilized by the warring powers in Europe at the present time on a large commercial scale.

The first two processes require a very large input of electric energy and the second requires in addition large quantities of raw material in the form of lime and coke.

The first two processes are receiving at the present moment a vast amount of publicity and it is generally acknowledged that their successful operation depends primarily on the ability to obtain extremely cheap electric power.

It is further being assumed that this cheap electric power can only be obtained from water-power development.

Some further consideration should be given to the third process which has been almost totally neglected in recent discussions. It is a well known fact that bituminous fuels contain an important percentage of organic combined nitrogen in such form that by treatment in processes such as the by-product coke oven the coal gas retort and lastly in the by-product gas producer, considerable quantities of ammonia are generated and recovered as a by-product.

It is not so generally understood, however, that in the by-product gas producer as developed in Europe during the last twenty-odd years approximately 70 per

cent of the available ammonia in the bituminous fuels can be recovered and made available, and that this percentage of ammonia is approximately four times the amount per ton of coal which can be recovered in a modern by-product coke plant or coal-gas plant. These by-product gas producers recover also a considerable amount of tar and generate besides these by-products a fuel gas which is entirely suitable as fuel for industrial furnaces, for the usual steam turbine plant or gas engines.

A complete power-producing unit of this character is, therefore, capable of solving two of our difficulties at the same time. It will furnish cheap electric power to be used in other processes and it will, also, as a by-product, produce a large quantity of ammonia suitable for fertilizer in peace times and convertible to nitric acid in case of war.

Some doubt has been thrown on the commercial practicability of oxidizing coal ammonia to nitric acid by some of our technical experts. There is no question, however, that this problem has been completely solved on a commercial scale in Germany. The writer has the records of a commercial plant which operated steadily for five years before the start of the war using coke-oven ammonia to produce nitric acid.

By the combination, therefore, of a power plant using by-product producers with ammonia oxidation apparatus we have a unit which produces ammonia and the resulting nitric acid together with a very large output of electric energy which may be applied to other industrial uses or to the production of further nitric acid by either of the other processes referred to above. The raw material which is required to produce this ammonia and electric power is bituminous fuel.

It is possible to demonstrate by using the most modern designs which have been adapted to American conditions that power can be generated in a plant of, say, 100,000 hp. capacity at a cost less than \$5 per horsepower per year, including all fixed charges. This is cheaper power than Niagara, of which we hear so much present talk. It has certain unmistakable advantages over Niagara power. Firstly, it is cheaper in first cost of plant. Secondly, it produces large quantities of a nitrate base and fertilizer as a by-product and the main product, either cheap electric current, or a good fuel gas is available for other electrochemical work or more nitric acid production. The obvious economy of this producer gas process lies in the fact that ammonia and tar worth approximately \$3 is recovered in the gasification of one ton of fuel. The cost of this ammonia recovery is less than \$1 per ton of fuel.

As an evidence that these remarks are neither visionary nor premature, attention is called to the fact that the German Government installed a plant of this character two years before the war started, at its central station at Heinitz, Germany. At the time the war started there were approximately eight plants of this kind operating in Germany. England has about forty such. The combined coal capacity of the plants of this type in operation abroad is approximately 2,000,000 tons per year. Japan has also four large plants and is about to build another large one. One of these is owned by the Japanese Government.

While the process is by no means experimental, nevertheless considerable development work has been done in a full-sized plant in this country during the past two years in adapting the foreign designs to American fuels and conditions. This work has demonstrated clearly the large possibilities of the process under our conditions when employing the latest mod-

ern designs. Mine refuse also has been regularly used in this plant; a material which had previously been considered utterly worthless.

The possibilities which lie in locating a by-product producer power plant adjacent to the bituminous coal mines and using the extremely cheap American fuels as a source of cheap electric power have not been appreciated in the recent discussions concerning the development of our water powers and other natural resources. In this respect the by-product producer industry is suffering under the same neglect which overtook the by-product coke industry after the first few failures of the foreign designs which were brought bodily to this country and installed and operated without carefully considering our local conditions and fuel characteristics. For many years the by-product coke industry in Europe enjoyed a rapid development while the industry here remained practically dead. At the present time, however, there is no question of the success of coke production with the recovery of by-products.

The problem of producing fuel gas for power generation with the recovery of tar and ammonia is one which promises to develop with equal rapidity during the next few years. In the opinion of those who have studied its development in Europe it presents no inherent difficulties and the recent demonstrations and development work to adapt same to American conditions have shown that its introduction here on a commercial scale is both practical and profitable.

It is particularly important at this crisis in our national affairs that we give full consideration to all possible means of conserving our natural resources in regard to electric power as well as of ammonia and nitric acid raw materials. It should not be forgotten, therefore, that we are destroying yearly the available ammonia in nearly four hundred million tons of bituminous coal. We recover at present only about 1½ per cent of the available ammonia which might be extracted from such coal by fully developed and well-known methods. In recovering the ammonia from these fuels by the producer gas process one merely converts the fuel value of the coal into fuel gas. This gas can be used in most industrial operations more readily than by burning the coal direct. If only 5 per cent of the available ammonia contained in these fuels which we are destroying were recovered we would have an ammonia base for nitric acid or fertilizer production which would make us entirely independent in peace or war, of foreign importations.

LEWIS A. RILEY, 2D.

New York City.

The Iron and Steel Market

No increase in activity has occurred in the steel market. Buying by the domestic trade continues very light, while export demand continues at about the proportions obtaining in two or three months past. The dullness in the domestic market is attributable solely to the season of the year, when new commitments are never undertaken in a large way. The pressure for deliveries of material already bought is substantially as heavy as ever.

As noted in the report of a fortnight ago, the dullness in the steel market serves to show the fundamental strength of the situation, as there is no wavering in the matter of prices and no seller is making a special effort to effect sales.

So strong does the market appear that predictions are occasionally made as to a fresh buying movement in the fall, and one of no mean proportions. Two months ago

such a prediction would have been considered visionary by practically all observers.

One element is present to induce buyers more readily to take hold, that being the large export demand. It was this influence that caused the first really aggressive campaign of buying in the domestic market a year ago. For months domestic buyers had been strongly of the opinion that during the war no really strong and active steel market could be developed. Then, in June and July, they modified their views to such an extent as to admit the possibility that export demand might perhaps become so great as to make steel scarce. It was the fear of such a development that caused the first really important buying in the domestic market, and it was months before it was realized that the export movement was not especially heavy, and that it was domestic business that was filling the mills.

Now, however, the export business has become much larger from a tonnage standpoint. Following is a summary of exports of the so-called "tonnage" products, those that are returned by weight in the government statistics, including scrap, pig iron, unfinished steel, finished rolled steel, pipe, wire products, etc.:

	Gross Tons
Monthly average, first half 1915.....	216,000
Monthly average, second half 1915.....	377,000
Monthly average, four months 1916.....	387,000
May, 1916.....	540,549

Export orders placed during the past two or three months suggest that exports during the remainder of the year are likely to be larger rather than smaller than those of May.

Shipments at Higher Prices

The advances in steel prices practically ended in March, and as the mills had been unusually reserved in the matter of booking open contracts the average invoice price of shipments has been approaching the current market level more rapidly than is usually the case in these upward market movements. As a check to such a generalization it may be cited that the estimated shipments of the United States Steel Corporation during the first six months of this year are substantially equal to the unfilled obligations the corporation reported for the close of business in December.

A further evidence that really high priced steel, steel averaging not far from current market prices, with, of course, various exceptions in special cases, is found in the remarkably high earnings reported by the Steel Corporation for the months of May and June. The monthly earnings have been as follows:

January.....	\$18,794,912	April.....	\$25,123,673
February.....	19,196,396	May.....	27,551,899
March.....	22,722,816	June.....	28,147,476
Quarter.....	\$60,713,624	Quarter.....	\$81,126,048

An interesting computation, not accurate, of course, but still quite illuminating, can be made. The corporation's daily shipments are assumed, from various data, to have increased from 47,000 tons daily in January to 51,000 tons daily in June. There were wage advances Feb. 1 and May 1, and the January, May and June earnings are corrected to what would presumably have been earned had the wage rates prevailing from Feb. 1 to May 1 been paid in those months. Finally, deductions are made for estimated profits in ore transportation in April, May and June. With these allowances the apparent profits per ton of steel shipped are computed roughly as follows: January, \$14.30; February, \$16; March, \$17.25; April, \$20.25; May, \$21.15; June, \$21.15. The computation is subject to considerable error, but it is sufficiently close to indicate that the rapid increase in earnings, due to higher realized prices, ended about May 1. Increases in earnings due to higher realized prices will come much more slowly in future. Incidentally, it

may be remarked that the Steel Corporation's earnings increased by more than \$20,000,000 from the first quarter to the second quarter, the third quarter is unlikely to show any material increase over the second. Shipments will be less, on account of hot weather, and the June rate of earnings is quite unlikely to be maintained.

Base prices of finished steel products, for shipment at mill convenience, are strictly maintained, and the market is very strong indeed in that respect. Premiums for early shipment, which decreased materially during the second quarter of the year, have shown, if anything, a slight increasing tendency in the past two or three weeks, plates being easily the leader in this respect, prompt deliveries being a shade higher than 30 days ago. Steel, as steel, is still scarce, and Bessemer is less plentiful, relative to open-hearth, than a month or six weeks ago, there having been fairly large buying by foreign and domestic consumers who set out to obtain open-hearth but contented themselves with Bessemer in order to secure desired deliveries.

Steel production has been materially curtailed by the hot weather of July. Labor is more independent than usual and yields to the influence of hot weather.

New construction work is proceeding very slowly, and the increases in steel making capacity month by month are relatively small, quite below the expectations.

Pig Iron

The pig iron market continues to drag along an uneventful course. There is neither buying pressure nor selling pressure. The buyers represent that they are well covered and have no occasion to take an interest in the market, nor do they admit that there is any prospect of their requirements increasing. The furnaces appear to be well sold up, and are quite content with the rate at which pig iron is being taken out against contract. Thus there appears to be an even balance, except for two possible circumstances. In the case of the foundries there have been labor troubles galore, and in some cases at least these have resulted in pig iron being piled in foundry yards. Should the melt continue to be restricted on account of labor scarcity and strikes the foundries might take somewhat smaller shipments in future, while, on the other hand, if they were able to increase their melt they might buy additional iron. The other circumstance that may affect the pig iron market is the action of the large steel interests. They are endeavoring to bring in new steel-making capacity, and their stocks of pig iron have become very small. There is a possibility of some of the large steel makers buying pig iron in the market, and the balance is now so delicate that in such an event price advances would probably be forced, and after such a long period of practically stationary prices the effect upon regular buyers, who are now indifferent, would probably be electrical.

Coming Meetings and Events

American Institute of Metals and American Foundrymen's Association, Foundrymen's Convention, Cleveland, Sept. 11-16.

American Institute of Mining Engineers, Arizona, Sept. 18-23.

Mining and Metallurgical Society of America, New York Section, New York, Sept. 21.

Second National Exposition of Chemical Industries, New York, Sept. 25-30.

American Chemical Society, New York, Sept. 25-30.

American Electrochemical Society, New York, Sept. 28-30.

Technical Section, American Paper and Pulp Association, New York, Sept. 25-30.

The Niagara Falls Power Famine

Meeting of the Committee on Foreign Affairs of House of Representatives and the Niagara Falls Board of Trade

At a luncheon-meeting given by the Niagara Falls Board of Trade to the members of the Committee on Foreign Relations of the House of Representatives at the Prospect House, Niagara Falls, N. Y., on July 13, 1916, the electrochemists presented their side of the power question in such a concise and convincing manner that we feel it a duty and pleasure to publish all the speeches in full.

Hon. CYRUS CLINE presided.

The members of the Committee on Foreign Affairs were welcomed to Niagara Falls in a gracious little speech by Mr. W. ACHESON SMITH, general manager of the Acheson Graphite Company, as one of the five men who now rule Niagara Falls under the city-manager form of municipal administration.

After luncheon Chairman Cline opened the formal meeting.

Mr. F. A. J. FITZGERALD, president of the American Electrochemical Society, was the first speaker:

It is very appropriate that something should be said to-day about the chemical industries of Niagara Falls, for it is almost exactly 21 years since the current from the Niagara Falls Power Company's generators was turned into the aluminium pots of the Pittsburgh Reduction Company and the greatest electrochemical center in the world was born.

The aluminium process, the first of these great Niagara Falls industries, was invented by the late Charles M. Hall and a few months later in the same year that master-inventor, Edward G. Acheson, started to manufacture carborundum. This, with the assistance a few years later of Jacobs' alundum, has revolutionized the abrasive industry all over the world. Shortly after the manufacture of carborundum started we had the first plant making Willson's calcium carbide. Then followed the great plants making caustic soda and bleaching lime by the process of Hamilton Young Castner and another great factory using the same inventor's method for the production of sodium. During these years Rossi was carrying on at Niagara Falls his experiments on ferrotitanium which have resulted in one of our most important industries. We have here also thousands of horsepower devoted to the manufacture of other ferroalloys such as ferrosilicon, so absolutely necessary to the production of steel. But it would take altogether too long to attempt mentioning all the developments of American inventive genius and enterprise which have flourished on the fertile soil created by Niagara power.

There is, however, another side of the subject which is by no means so cheerful, for the brilliant prospects of a few years ago are becoming dim. Since the great war broke out public attention has been strongly directed to the manufacture of nitric acid from the air; but, outside of technical circles, very few people know of the pioneer work done on this problem by Bradley and Lovejoy at Niagara Falls. Their work soon showed that for the successful working of the process enormous quantities of cheap power would be required and consequently the enterprise was never brought to a commercial basis. Yet to-day there are less efficient processes than that of Bradley and Lovejoy working in countries where sufficiently large quantities of power can be obtained.

There is a widespread but erroneous belief that the development of the electrochemical industry will spoil the scenic beauty of the Niagara Falls and this undoubtedly seriously threatens the existence of the industry. Again in this relation we hear much about the exploitation of natural resources by private interests and the consequent injury to the public. But as so often happens in cases like this the real interest of the public has not been considered. For this oversight neither the public nor our legislators are to blame simply because those who know better have never taken the trouble to explain to others the relation of Niagara Falls industries to the public at large and how every citizen of the United States is vitally interested in them.

Now, at the eleventh hour, when these industries are facing a serious crisis those who realize what this means

are anxious to devote all their energies to giving the widest publicity to what they know.

Mr. FRANK J. TONE, works manager of the Carborundum Company, spoke of the Niagara electric furnace companies as follows:

In speaking of the electric furnace industries here, I wish to mention very briefly how these industries have originated, what products they make and more especially what an essential part these products have become in the industrial life of this country. Our electric furnace industries comprise aluminum, calcium carbide, carborundum and the artificial abrasives, ferroalloys and artificial graphite. In the first instance these products have all been made possible by Niagara power. Most of them were discovered a few years previous to the development of power here, and in 1895 some of them were struggling along with steam power, some were laboratory processes and some were still laboratory curiosities. When electric power became available here in large quantity and at a reasonable price it became possible to develop these new metallurgical products on a commercial scale and now they have become so indispensable that a failure in the supply would be a calamity to some of the greatest industries of the country.

Take for example the making of steel, the greatest of all American industries. In 1915 we produced 28,000,000 tons of steel in this country and in two-thirds of this there was required ferrosilicon, an absolutely essential element in producing sound castings and sound ingots. At the beginning of the war all the ferrosilicon used in this country was made by Niagara power in plants located both here and on the Canadian side. The Dominion Government at once placed an embargo on the exportation of ferrosilicon to the United States, all of this alloy being required for use in Canada and in Great Britain. This threw the burden of supplying the American market entirely upon the ferrosilicon works at Niagara Falls and caused an acute shortage which still continues. A cessation in the supply of ferrosilicon would shut down every steel mill in America.

Silicon metal is another Niagara product of importance to the steel industry. It is used in making transformer steel for electrical apparatus and greatly reduces the electrical losses. It is saving millions of dollars annually wherever electrical energy is being transformed. It is also used for the generation of hydrogen for dirigible balloons and balloons for military purposes. Every army in Europe to-day is equipped with apparatus for the use of silicon in connection with their observation balloons.

Perhaps the most striking illustration, however, of the dependence of industry on Niagara power is that of high speed steel. This requires in its manufacture the alloys ferrochromium, ferrovanadium and ferrotungsten. All these are products of Niagara power. Before the invention of high speed steel when we used ordinary carbon steel, a metal cutting speed of 15 ft. per minute was commonly employed. Contrast this if you will with what may be seen in any machine shop where a tool of high speed steel running at a red heat at a speed of 40 or 50 ft. per minute is taking off chips $1\frac{1}{2}$ in. wide and $\frac{1}{2}$ in. thick. High speed steel has tripled the capacity of every machine shop in the world and the efficiency of every workman. It has cut to one-third the capital investment in plant required to accomplish a given volume of work. This is due to ferrochromium, a product of Niagara power.

Ferrochromium is also the hardening agent used in making armor plate and armor piercing projectiles. Without it we would be unable to equip a single battleship with protective armor or serve a single coast defence gun with modern projectiles.

The battleship Pennsylvania, our latest dreadnought, has 10,000 tons of armor. This required in its manufacture 300 tons of ferrochromium. That is to say, 12 carloads of a Niagara product has gone into the battleship Pennsylvania, and if the United States is going to embark on a broader naval policy one might ask, "Where is the ferrochromium coming from?" It certainly is not coming from Niagara Falls unless there is a change in the power situation here. I might answer that if things continue as they are we will go to Canada or Norway for ferrochromium for our armor plate.

An armor piercing projectile is an interesting product. Fired at a distance of 8 miles to pierce 12-in. armor plate, it must have an energy of 30,000 full tons or twice the energy of a modern express train running 40 miles per hour. It pierces the plate and passes completely through it without suffering deformation. This is because the point is made of chrome steel produced from ferrochromium, a Niagara Falls product.

Another product that Niagara Falls power has brought

into every day use is a metal aluminium. It was the pioneer industry to use Niagara power and its beginnings were small. Last year the production was 80,000,000 lb. It is used in electrical transmission conductors, cooking utensils and various metallurgical purposes, but perhaps the most important use is as a structural material in aeroplanes and automobiles. The shortage to-day is very acute and is regarded by automobile engineers as little less than a calamity.

Calcium carbide is also a product of great importance to industry. We know it best in the acetylene lighting of towns, isolated buildings, miners' lamps and harbor buoys. However, by far its most important use is in the oxy-acetylene flame for the welding and cutting of metals. In the steel foundry we see an oxy-acetylene flame cutting sprues of castings and replacing 12 men working with the old methods. Several years ago, when the Quebec Bridge collapsed, engineers said that it would require as much labor to remove the wreck as it would to put up a new bridge, but it was found that these huge twisted girders could be cut up very successfully by the use of the oxy-acetylene flame. Without the oxy-acetylene flame the battleship Maine could never have been chopped up and removed from Havana Harbor. When the steamer Eastland turned turtle in the Chicago River it was the oxy-acetylene flame that made it possible to quickly cut a hole in the hull and rescue scores of passengers. It is Niagara Falls power that has given this wonderful tool to industry.

Other important Niagara products are carborundum and alundum, artificial abrasive or grinding materials. They are fundamental elements in the metal-working industries and Niagara Falls has always been the sole seat of the industry in America. At the beginning of the war the supply of the natural abrasives, Turkish and Grecian emery, was entirely cut off and it became necessary for the artificial abrasive manufacturers in the Niagara district to supply the entire demand. This has resulted in an acute scarcity of the product. The shutting off of the supply would have crippled the great metal working industries of the country such as automobiles, locomotives, agricultural implements, electrical machinery, paper-making machinery, flour milling machinery, firearms and all manufactures of steel, iron and brass. For example, take the automobile industry. The perfection of the modern automobile and the interchangeability of its parts have been largely brought about by the development of the modern grinding wheel. Practically every part of the automobile is ground at some stage of its manufacture; crank shafts are roughed and finished with grinding wheels, likewise cam shafts, pistons, cylinders, ball bearings, etc. It is no exaggeration to say that if the automobile manufacturer was now deprived of artificial abrasives and compelled to go back to the grindstone, and at the same time we took away the other products of Niagara power, aluminum, oxy-acetylene welding and high-speed steel, a works that now produce 500 cars per day would be reduced to an output of 100 cars per day with the same plant and same workmen and the cost would be correspondingly increased. In fact, there would be no automobile industry on its present existing lines.

A word in regard to the power situation in the abrasive industry because it is typical of many Niagara industries. The Carborundum Company has a plant with an electrical capacity and a furnace capacity of over 20,000 hp., and all the power it can get to-day is 10,000 hp. for a continuous 24 hr. load. It has therefore constructed a works in France of 7000 hp. capacity and is bringing all the product over here for distribution to the American market. As the situation has become more critical during the past few months it has decided to build a plant across the river in Canada using Niagara power, and this plant is now under construction. Practically the entire output will be brought over for use in the American market.

We are striving to-day to make America industrially self-contained, but while the demand for the products of Niagara power by the great and basic industries of the country is increasing at a very rapid rate, our ability to supply these products is by no means keeping pace with the demand. It does not even remain stationary. Our ability to meet the demand for these essential products of the electric furnace is actually decreasing month by month.

Mr. A. H. HOOKER, technical director of the Hooker Electrochemical Company, in speaking of the Niagara electrolytic industries, addressed the committee as follows:

During your trip in the automobiles on Buffalo Avenue as you turned and came back, the plants farthest up were the Oldbury Electrochemical Company and the Phosphorus Compounds Company, where they are making chlorates

and phosphorus and its compounds, products which are vital to the match industry of the country. Phosphorus also finds an important and irreplaceable use in the metal industry as a deoxidizer and hardener in many non-ferrous alloys, chiefly in the phosphorizing of copper for the manufacture of phosphor bronze used on battleships and for certain bearings on machines. The use of chlorate in gunpowder is also known to all. Next to these plants in line is our own plant, the Hooker Electrochemical Company, to which we have made large additions in the last year; directly across the road is the Niagara Alkali Company. Both plants make caustic soda and chlorine products.

I shall tell you something about some of the uses of these products. For instance, in the paper industry chlorine in the form of "bleaching powder" is used; for every 100 tons of book paper there are 20 tons of bleaching powder used. So you see what a vital product it is in this industry. Then it is an all-important disinfectant. The water in a thousand cities of this country is by the use of "chloride of lime" or calcium hypochlorite, or free chlorine, sterilized to a point where we need no longer have typhoid epidemics. Our own city, Niagara Falls, is a wonderful example of such use. Not long ago Niagara Falls was a typhoid fever plague spot—nothing less—caused by our use of water polluted by the sewage from Buffalo and other cities; but now that is all changed and we have not had a single case of typhoid; no, I won't say a single case, but practically that—since this same chlorine treatment of our water was started. I leave it to your imaginations to see whether or not other cities will not follow our example and use this product for the same purpose until it has become invaluable for the purification of our water supplies. Our own army is now using the same chlorine treatment to avoid the dangers from typhoid which beset our soldiers during the Spanish-American war. In Europe the best preventive of blood poisoning and infection from dirty wounds is reported to be a mixture prepared from "chloride of lime" or "bleaching powder." Without this same "bleaching powder" our cotton dresses and sheeting would no longer be white; our shirts and collars from the laundry would be a dirty yellow; and, what is worse, a serious menace to health would result through lack of disinfection. Also, white cotton batting, bleached shellac, chloroform for surgical operations, even the disinfection of our garbage and sinks, call for chlorine in the form of "bleach." This same chlorine is used for the production of carbon tetrachloride, which in the form of "pyrene" has become a household necessity as a fire extinguisher.

Chlorine is used to-day not only in the form of "chloride of lime" for bleaching, for the bleaching of paper and textiles, but it also enters into a wide number of products that we do not ordinarily think of. For instance, a large addition recently made to our plant has been for the chlorination of benzol. Chlorbenzol is one of the coal-tar intermediates which this country has never before produced. Prior to one year ago I believe there had not been 200 lb. of chlorbenzol made in this country—I think we made something like this amount at that time—but to-day there is being made many thousand times that amount right straight along.

By passing chlorine gas into benzol or toluol there is formed hydrochloric acid and chlorbenzol or chlortoluol and the latter products can then be used to form picric acid, benzoic and trinitrotoluol, etc.; it is equally desirable for the production of sulphur black used for a dye, for instance of your socks, and for the production of carmine reds that are used on our automobiles and cars and agricultural implements, and hundreds of other directions in the manufacture of dyes. So for explosives in time of war or for dyestuffs in time of peace, we are getting ready to be of service.

These industries which we have developed and those which we are starting now, for which the country feels such an urgent need, we want to keep in this country, and want to keep them here permanently. I do not see how we are going to continue with the power situation as it stands to-day. We have taken the risk of putting a large sum of money into these new industries, and we have got to grow, or else, as with everything else, we shall reach a point of stagnation. That growth will require more power, not less, as times goes on, because we have got to have additional products; and so it is all down the line, the same proposition occurring all through the electrochemical industries.

Take caustic soda, so vital to the soap industry, so vital to the manufacture of artificial silk, the refining of oils and the mercerizing of cotton, the manufacture of dyes, explosives, cleaning of metals, etc., I believe you all know what household lye is, what caustic soda is, and what a vital part it plays in our many industries and how important it is

to our whole nation. The two plants named above and the pioneer company, The Castner Electrolytic Alkali Company, which make caustic as well as chlorine compounds, are absolutely dependent upon Niagara Falls power, and turn out a great deal of the caustic soda produced in this country.

When you get down a little farther on your trip you came to the plant of the Niagara Electro Chemical Company, making metallic sodium, using this same caustic soda produced at Niagara Falls. This metallic sodium is converted into cyanide, and upon this product depends your gold and silver mining industries, the plating industry, etc. The country being cut off from the supplies of German sodium cyanide, it looked for a time as if our mining industries would be seriously affected, but with enlargements and increases in our own production we have been almost able to hold our end and keep up with the necessities. A great deal of cyanide is used in killing the enemies of citrus trees, and California citrus fruit crops are dependent somewhat upon cyanide made from Niagara power.

From sodium is made sodium peroxide from which again is made hydrogen peroxide, which is used for bleaching and which also is used in the household. From sodium peroxide is made a material which is used as a source of purifying air in submarines, in life-saving work in mines, hospitals, etc. I speak only of these as a few of the different electrochemical products we are making here at Niagara Falls, and their relation—their vital relation—to the industries of the country.

I well remember a little situation that came up to me in December as showing this condition. A cotton batting mill had neglected to make contract for bleaching powder. They possibly thought it would come down in price, or else neglected it, thinking it not a very important item in dollars and cents, as the price of the product was cheap—a little over a cent a pound. However, they had no contract and came to us in December and wanted to know if we could not supply them with "chloride of lime" to keep them going. I said that I did not know, but would take the matter up with our New York sales office. I telephoned to our New York office, but our company could not supply them, but they did make some arrangement whereby they were able to keep this plant running. The situation was simply this, that the whole country was absolutely swept clear of these chlorine products and they could not be got for love nor money.

I might cite another instance: One of our largest stockholders was using a small amount of bleaching powder. He wanted to buy some small amount of bleaching powder from us, but had no contract and our supply was exhausted. We tried to get some bleaching powder for him and we had to pay \$250 a ton because of the shortage of these products, although we were selling the bulk of our supply for perhaps \$25 per ton.

This simply goes to show the effect of the shortage and the necessity for these products that are made in Niagara Falls, the center of the chlorine industry of the world, and it also shows how vital these products are to the full, economic life of the country. Still it seems like a little thing which you hardly ever think of. So when we have started plants here, if we cannot get the water power to develop them to that stage which is necessary to keep up with the normal demands of the country, or to meet such special contingencies as when the country was shut off from foreign supply by the war, it simply finds every one of these industries in a position where it has to look for another source of power. As Mr. Tone has said, we will have to develop a plant in France or Canada or elsewhere. We have got to grow. We cannot stand still. We have got to have more electrical power, or else we simply lose what we have had in America—the greatest center of the electrochemical industry in the world; and this is a great deal more of an asset to the country than the dye industry has been to Germany. Simply for lack of power we are letting our industries scatter, here and there, over to Canada and elsewhere, instead of keeping them for the benefit of our own country. It certainly seems that we should keep our industries right here, and that some means should be devised to utilize the maximum power from the Falls.

We cannot stand still; we have got to grow.

Mr. I. R. EDMANDS, consulting engineer of the Union Carbide Company, was the next speaker and made a positive suggestion as to how to go about in order to get a new international agreement:

I believe you will all agree that the power that has been developed at Niagara has been a tremendous help to the people of this country and Canada, by increasing domestic and civic convenience and aiding industrial development.

I believe you will all agree that all the 20,000 cu. ft. per second of the flow of the Niagara River allowed us by treaty between United States and Great Britain, should be used and also that the 4400 cu. ft. of this amount not now being used is a big mistake, as it is a wasted available and desired resource of this country.

I believe you will all agree that every cubic foot of water in the Niagara River that is not needed to maintain the scenic beauty and grandeur of the falls should be put to useful work.

The big question is how many cubic feet of water can be diverted from the falls without diminishing their beauty and grandeur. After several years of careful measurement and observation of some able government engineers, they decided that 25 per cent of the entire water of this river could be diverted without detriment, and on their reports the amounts set forth in the present treaty were determined. Over 21 per cent of the normal flow of the river is now being used and no appreciable diminishing of their beauty is noticeable, and it is very evident that much more can be used without detriment.

An eminent engineer living at Niagara, who has made a careful study of the effect of flow condition on the scenic feature, believes that by proper placing of submerged dams above the falls, 50 per cent of the normal flow can be diverted without detriment to the scenic beauty. If he is right, what a crime is being perpetuated on our natural resources! An additional 25 per cent of the flow of Niagara River at the falls represents about one million horsepower, or, if developed by steam, the use of about six and one-half million tons of coal per year. Shall we continue to let this water run to waste?

Strenuous efforts should be made by our government to help get this water in use, instead of the present methods of restricting it.

If the use of water in excess of that allowed by the present treaty is contemplated, there are many existing interests which should be considered.

But who will take the initiative?

As a suggestion, why shouldn't Congress arrange for the invitation of a commission to investigate the further diversion and use of water from the Falls to the full amount possible, still maintaining the scenic beauty and grandeur and without harm to navigation; then have it make recommendations to the United States and Canada for further action.

This commission could be made up of representatives of the various interests involved, such as one from the Dominion of Canada engineers and one from the United States Government engineers, one from Canada and one from the United States representing the public interest in the scenic grandeur of the Falls, one from each country representing the existing power companies, one from each country representing industries using Niagara power and one from each country representing navigation interests, also one from each country of the members of the International Joint Commission.

The Commissioners should be empowered by the interests they represent to energetically spend as much time and money as is necessary to obtain proper information and engineering data required, on which to base their recommendation to the two governments.

I wish to submit this for your consideration.

Mr. F. A. LIDBURY, manager of the Oldbury Electrochemical Company and a past president of the American Electrochemical Society, spoke as follows:

Our guests to-day may have noticed that the speeches and in general the talks they have heard possibly differ in one important respect from those they are accustomed to hear when they visit specific localities on specific problems. I think we can claim there has been nothing local, nothing sectional, presented to-day. We have tried to present this as a national matter, a matter of extreme national importance.

There is one very difficult problem in connection with the power situation at Niagara Falls, and that is the problem of getting into the minds of the people at large a thorough understanding of what the power development at Niagara Falls means and has meant to them. There are problems of considerable importance, analogous problems, where this difficulty does not arise, and we have all seen in the last year or so, the problem of the dye industry discussed with a great deal of intelligence, simply because the average individual, the everyday member of the public, understands what the production of dyes in this country means to him and what it means to him to do without it; but it is extremely difficult to get a layman to understand what the electrochemical production of this city means to him.

though the importance of that production is, I venture to say, several thousand times the importance of the dye stuff industry in this country.

Now, why is that? It is because he is only affected indirectly. Though in everything he does, in every activity he indulges in, from the time he gets up in the morning until he goes to bed, he is enormously benefited by the electrochemical production of this city. He does not know this because he does not eat bleach, and he does not wear phosphorus, and he is only reached indirectly through a number of stages, and he does not know what these stages are.

An attempt has been made by the papers which have been circulated amongst you and the speeches which you have heard to give you a few—and only a few—of the most important lines along which the electrochemical industry has directly and importantly influenced the industries of this country; but it must be realized that a phenomenon that has been one of the most significant things in industry in the last fifteen years cannot be discussed in fifteen minutes. We realized, we electrochemists have come to understand that not the power companies, but we, are the crucial point in this situation, and it is up to us, and it is a matter of duty for us to get before the people and their representatives exactly what we do and what we need. Now, that is what we are trying to do, and it is very difficult; but there is one thing we have to say to you gentlemen, and that is that the American Electrochemical Society, of which the present president and two past presidents are before you to-day, is most anxious to get before you all the information on this subject that it can, and it stands ready to send out representatives at any time to Washington to give you all the information at their disposal at any time you want to send for them. It is impossible to do it in a few minutes' conversation, but we do feel that we have said enough to-day, and these papers that you have got, if you will read them, will show you enough to indicate that this is really not a matter of secondary, but a matter of primary, importance to the people of this country.

I referred to the dye stuff situation and to the general appreciation of the results which will follow any extreme shortage of dye stuffs. The results which would follow an extreme shortage of the electrochemical products made in this town are something that no man here could describe. They would have to be experienced to be understood. The mildest way in which I can put the matter to you gentlemen is this: That if it had not been for the existence of these industries in this town, in the last two years, instead of this country having had an industrial boom, it would have had one of the greatest industrial depressions it ever has experienced. You have only to take what Mr. Tone said in regard to the steel industry to understand what would have been involved.

The electrochemical industry in this country is something of which we ought to be extremely proud. We hear a great deal about Europe being ahead of this country in chemical industries and similar lines, but there is one branch of the chemical industry in which this country has never had to take a back seat to Europe, and that is the electrochemical industry. As has been pointed out, this town is the chief electrochemical center of the world, and in fact some of the most important electrochemical developments were born here. This is particularly true of those industries which have had the widest and most important influence upon industries in general.

Now, we are not only proud of this development in general, but we are proud—and we have a right to be proud—of the resources and energy with which the electrochemical industries of this country, and specifically of this town, have, under conditions of extreme difficulty, in certain respects, come to meet the situation in the way of increased demands or the substitution of one article for another, that has taken place since the war began. It would take too long to describe this, to explain in detail what has been done; but let me refer to just one specific case which involved throwing over one industry in order to bring up the production of ferro-silicon to a point where it could be of considerable assistance to the steel makers, deprived of foreign production.

The one thing I want to bring to your attention is what the present conditions are and what the outlook is. Ever since power restriction measures came into effect, there has been noticed a tendency, which recently has resulted in an acute condition, to shortage of power on the American side of the border here, and increasing prices, and greater stringency in contract conditions. The vital requirement of the electrochemical industry is abundant power and cheap power. *Dear power is no good to it.* As a result of these conditions, which started to show themselves immediately the power-restricting measures took effect, there was a tendency to the migration of plants which either originally

began operations here or which would have naturally commenced operations here, to other localities; and I want to specifically call your attention to the fact that the majority of those migrated and the most important of them have been to other countries.

As early as 1907 the first fixed nitrogen plant on this continent was projected. That was the American Cyanamid Company. After carefully looking around and seeing what could be done in the way of power sites in the United States, they decided to locate on the Canadian side of the border, just over the river here, and are to-day consuming something over 27,000 hp. in the manufacture of cyanamid, the market for which is entirely in the United States. The two companies which have revolutionized the abrasive industry have found it necessary to move the greater portion of their furnace operations to Canada, and in one case to France. Recently we have seen the Union Carbide Company erecting a plant to consume 100,000 hp. in Norway, and although it is not yet known where the products is destined for, the principal outlet, it is generally understood, will be in this country.

We can only judge the future by the past and by what we see going on before us at present. What we see to-day is a tendency for these industries to leave this locality because of the lack of power, and to go, not to other parts of this country, but to other countries. Now, why is that? Outside of the power that has been developed here and that can be developed here, there are practically no water powers which offer sufficiently favorable conditions, or which show any prospect of offering sufficiently favorable conditions, for these industries; and there is a very good reason for that. There are lots of water power in this country, and I dare say there are lots of power which can be developed cheaply. Most of it is in the West. Now, the electrochemical products which consume this power have to be transported from one section to another. You can carry them just so far economically, and no farther; and it happens that the consumptive outlet for the majority of the products that are made in Niagara Falls, is in the manufacturing districts of the East. That is, of course, natural because these products are fundamentally important ingredients of the products of the most important industries of the country; consequently, to locate out West is to put a prohibitive transportation cost on the materials; in fact, calculations show that for the purpose of supplying the Eastern markets, the majority of the processes now at the Falls would have to get the power on the Western coast, not only for nothing, but would have to get as much as a bonus as they have to pay for power here!

So if industries move to other parts of the country, they have to go to localities from which they can transport their products cheaply to the manufacturing centers of the East; hence, their location in Canada, particularly those portions of Canada which are near the border here, and which have water transportation, and their location in places such as Norway, from which water transportation is cheap and easy to the Eastern seaboard of the United States. Bad as power conditions now are here, they are likely to become worse. The Dominion Government has reduced the amount of power for which Canadian export permits are given and has served notice of its intention to reduce the exported quantities yearly at a rate which will bring exportation to a complete stop in the course of six or seven years. As at least one-third of the Niagara power used in the United States has been imported from Canada, we are faced with a further curtailment of our already restricted operations. Unless immediate and substantial relief is given, the already insufficient output of our electrochemical plants will be seriously and steadily reduced.

Now, gentlemen, here is the question that we have got to face. Are we going to utilize our natural resources in this country to permit of the further normal development of these industries, which are of fundamental importance to every one of us, or are we going to close our eyes and let things take their course and see these industries gradually expatriate themselves? We have our choice. There is no third way. We have got to make up our minds that we have either got to develop these industries in this country or see them go abroad. It is easy to keep them. All we have got to do is to utilize, instead of allowing to go to waste, those natural resources which have been given to us and which cost us nothing. I think enough has been said to-day to give you an idea of what the frightful consequences may be if such another dislocation of the world's trade comes—if we get into a war ourselves, or if other nations going to war dislocate the world's trade—if we have allowed these industries which are so fundamentally important to grow up, not where they were born and where they ought to be, but in other countries. That is the proposition which faces us.

Now, I do not think that there is any consideration which

is more important in this regard than an answer to the question so frequently put: What has the country got for the alleged spoilage and destruction of the scenic beauty of Niagara, this, that and the other thing that the alleged vandals have done at Niagara Falls? That answer is simple, plain and emphatic. All of you gentlemen know, and know thoroughly well, the effect of the scientific contributions to industry in the last fifteen or twenty years. You know thoroughly well that by those contributions the productive power of each individual in this country has been enormously increased. If you analyse the nature of these improvements, taking the mechanical industries, for instance, which this country is particularly ahead in, and you find that the ability of one man to produce to-day what several men produced before is due—what to? To the contribution of the electrochemical industry to tool steels and to the technique and materials of grinding. The same thing—dependence on the products of Niagara power is true in practically all the industries which have so enormously been improved in the last twenty years, and whose improvements by adding so greatly to the productive power of the individual, have enabled every man in the country to obtain a better and richer existence. That, gentlemen, is our answer to the question: What have you vandals done with Niagara Falls?

Dr. EDWARD ACHESON, the world-famous inventor of carborundum and artificial graphite, was the last speaker. His speech deserves to be called a classic:

Mr. Chairman and Gentlemen of the Foreign Affairs Committee of the House of Representatives:—I understand the purpose of your present visit to Niagara Falls is to give you an opportunity to form a clear and accurate judgment for or against the advisability of permitting a further diversion of water from the Niagara River for power purposes, and, further, its bearing upon the international relations between the United States and Canada.

I have been honored with an invitation to address you, and it is with great pleasure I grasp the opportunity to place before you a few facts which, I hope, you will consider of sufficient importance to bear weight in the formation of your decision.

With your kind permission, I will give you a brief glance at my own activities in and about Niagara Falls, and the results I have been able to accomplish, my excuse for presenting my own affairs to you being that I know them better than my neighbors. There are, however, many other manufacturers who could advance equally strong arguments as those I am about to place before you.

In 1894 I was located in Monongahela City, in the very heart of the bituminous coal fields of Pennsylvania. I was operating a small plant manufacturing carborundum, the production during that year amounting to 52,190 lb. The electrical power for the operation of the furnace, in which carborundum was produced, cost too much money to permit of the material being sold for general grinding purposes.

The first electric power plant erected at Niagara Falls was approaching completion. I came to this city and contracted for 1000 electrical horsepower, built a plant, and during the year 1896 the production of carborundum jumped up to 1,100,000 lb. During the following years the business grew until, during 1913, the production amounted to 20,033,000 lb. Since 1913, the business has shown considerable fluctuation, having dropped to 16,410,100 lb. in 1915, but during the present year—1916—it is running at the rate of 22,433,600 lb., this being the maximum possible production of the plant under the present curtailed condition of power production.

While you will notice that the production in 1916 shows an increase of 38 per cent over 1915, during this year the orders have been coming in to the Carborundum Company at such a rate as to represent an increase of 120 per cent over that of 1915. Notwithstanding these facts, the company has not increased the price of its goods.

It will not be necessary for me to comment upon the great value of this grinding material in the manufacturing world, it now being practically a necessity in many lines of manufacture.

My second venture in commercial manufacture at Niagara occurred in 1900, 16 years ago. It consisted of the manufacture of artificial graphite. The development of this new business has been as follows:

In 1900 the production amounted to 860,750 lb. The following year it had jumped to 2,500,000 lb., and in 1913 it was 13,633,342 lb. This business, you will notice, was developed before the European war had taken form; hence, it had not been influenced by these world disturbances.

Since the beginning of this present year, 1916, the orders for graphite received by the Acheson Graphite Company

have been at the rate of approximately 50,000,000 lb. per year. The company's present plant has a maximum capacity of 40,000,000 lb. per year; while owing to the unfortunate curtailment of power production, only sufficient power can be obtained to produce approximately 20,000,000 lb., and the company faces the further unfortunate condition of possibly being reduced to two-thirds its present output, or 14,000,000 lb., by reason of the Canadian Government having called for a large amount of power now being utilized in the United States.

Let us more closely examine these orders for 50,000,000 lb. of artificial graphite. They are for a material that did not exist 16 years ago. The coming into being of this material has permitted the creation of vast enterprises previously impossible. For instance, as an example, we will take the manufacture of caustic, bleach and chlorine, all important to our present-day life. Competent authorities have stated that their efficient manufacture would not be possible did the artificial graphite not exist. The existence of this Niagara-made graphite has been of incalculable value in hastening the liberation of the United States from the necessity of buying foreign-made products essential to our welfare and growth.

Alongside of and coincident with the growth of these domestic values, is the fact that no less than 29 per cent of this year's business of the Acheson Graphite Company is export trade. Further, these orders from abroad would have been vastly greater had it been possible to fill orders that could be had for the mere asking, and this is happening at the very time Norway, with her great water powers, is becoming restless and shows signs of wishing to enter the world's market with an artificial graphite.

Is it not worth while caring for this export trade? We are at this moment witnessing a great movement of the American manufacturing world towards the creation of a vast export trade. The Government is taking a friendly interest in this movement. Are these Niagara Falls interests too small to be taken into account?

You are, perhaps, thinking and may say I am an interested party, and am only hoping to advance my own interests, but it is possible you may not think so badly of me when I tell you the Acheson Graphite Company has not advanced its selling price one cent since this on-rush of orders. No advantage has been taken of the present great demands for its products.

My purpose in giving you statistics regarding these enterprises is not with the hope of your rendering me assistance to advance my own interests, except as they may be advanced with others. I am presenting them to illustrate what may be done with Niagara Falls power in furthering the interests of our country at large. Many of the products produced in this city are absolutely essential to the successful operation of industries in cities and towns far removed from Niagara Falls.

You may say this is all very good, but why not manufacture these materials somewhere else and preserve the Falls? This brings us to the very heart of this whole matter. Previous speakers have already answered this question better than I am prepared to do. This subject is, however, very much greater than the simple matter of supplying more power and greater facilities to the factories of Niagara Falls. It is nation-wide in importance. You, as a Committee of the National Congress, have a duty to perform and a great responsibility rests upon you.

While you are with us, you will not fail to be impressed with the fact that this is a novel industrial community. Niagara Falls is no longer the pleasure resort of former years. The scenic beauty of the Falls is still with us, but the true value of the Falls and this community, in so far as the country at large is concerned, consists in the vast quantities of manufactured products distributed throughout the world from our local factories, many of which were only made possible of commercial production by the generation of electricity through the diversion of water from the Niagara, and in the invisible, vibrating current of power sent out on radiating threads of copper to cities, towns, and villages within a radius of 100 and more miles. Many of the factories located here on account of the power being cheaper. They have grown to large magnitude, and it is not an easy matter to move them to other localities.

I wish I had the gift of ready language, that I might better impress you with what appears to me to be your opportunity to use your great influence and directing power in bringing about a movement which would be of incalculable benefit to our entire country, and more particularly to our posterity. Would that I might make one small remark that would cause you to depart from what, to me, seems a wicked course—the failure to properly use our great natural resources. We are at the present moment within hearing of the roar of one of the most stupendous forces in the

world. Magnificent and grand from the scenic point of view it certainly is, but to me it would be much grander and more impressive were a large portion of this vast power being utilized for the present and future welfare of man.

I consider it a veritable crime against our posterity to preserve this great natural, inexhaustible resource in its entirety, or as it now is, for reason of its scenic beauty while we at the same time press forward to the exhaustion of the coal deposits of our country.

We are advised our coal supply will be exhausted in another century. Certainly a goodly time, but still not great as we measure the life of nations. There is nothing visionary or fanciful about this early exhaustion of our coal supply. True, we are told of immense coal fields in Alaska, but one cannot readily imagine the factories of New York, Pennsylvania, Ohio, or, in fact, any of the States being supplied from these deposits in the frozen North. Let me impress upon you the fact that a century is not a long period. Three generations will more than cover it. An instance in my own family will well illustrate this. Among the treasures of the family is an invitation from President Washington to one of my grandfathers to dine with him, my grandfather at that time being a member of the Pennsylvania Legislature, and this was more than a century ago. Our own grandchildren may witness the practical exhaustion of our coal if no steps are taken to conserve it.

I have here a few statistics coming from the U. S. Geological Survey: The production of anthracite coal in 1913 was 91,524,927 metric tons. Compare these figures with the production in 1820, which I find was no more than 365 tons, and this was two years after the birth of my father. Here are figures on the production of bituminous coal in the United States: In 1895 it amounted to 124,627,000 metric tons. In 1900 it had increased to 191,256,000 tons, and in 1913 it had jumped to the great figure of 478,523,000 metric tons. You will not find it difficult to see the exhaustion of the coal deposits a century hence.

Perhaps you are not interested in the welfare of the people who will live a century hence, but I assure you that if those people find that a great natural, inexhaustible resource for power, as is the Falls of Niagara, has been preserved to them on account of its scenic beauty, while at the same time the country has been denuded of its coal supply to produce power, these far-away people will be very, very much interested in what you and all of us, of this present generation, have been doing. Unless we have already done so, they will find themselves under the necessity of diverting the water from the river for power purposes; hence *they will have neither coal, which we will have used, nor scenic beauty, which we are trying to preserve.*

In closing, gentlemen, permit me to leave with you the question, "*What is the true, the real conservation of our natural resources? Is it not the full and economic use of the inexhaustible for the preservation of the exhaustible?*"

The Coal-tar Dye Industry, Past, Present and Future*

BY BERNHARD C. HESSE

For the past twenty years or thereabouts the United States has had within its borders a supply of coal-tar materials of suitable quality and in sufficient amount to produce all of its own requirements of coal-tar dyes if it so chose to use them; for the same period of time it has had domestic access to substantially all the needful other or auxiliary chemicals, except sodium nitrate, in which respect it was dependent upon Chile, and in that regard it was in the same position as practically every other nation; to-day we are in most favorable position in these respects. So far as men, experience and equipment are concerned we are now in better condition than ever before.

In the early days of the coal-tar industry, Belgium, France, and Great Britain had the largest domestic supplies of coal tar and other materials, whereas Germany was not so situated, but was dependent upon these three countries for the major portion of these materials. The coal-tar dye industry was started in England and France fully four years before it was

started in Germany; within the first fourteen years of its life, i.e. by 1874, the German coal-tar dye industry made 90 per cent of the coal-tar dyes then consumed in the world.

From the comparatively small number of dyes which constituted the coal-tar dye industry of 1874, say 50 different dyes, this industry has now grown to more than 900 different dyes, involving more than 300 other chemical products, themselves not dyes, but needful in the making of the dyes proper. The activities that led to the development of the dye industry brought about with them phenomenal development in synthetic medicinal, and pharmaceutical products, synthetic perfumes, photographic chemicals, explosives, disinfectants, and means of scientific study and investigation which were not foreseeable a half century ago. Collateral thereto, but none the less important, the technique, information, and point of view so evolved has had a mighty and stimulating effect upon many other branches of chemical-industrial endeavor all outside coal-tar chemistry. Few, if any, chemical activities have been so catholic in their fields of endeavor and so all-pervading in their effects.

Fifty years ago the commercial future of the coal-tar dye industry seemed limited; its possibilities, direct and indirect, did not appeal with any great force to any but the Germans; the industry as it stands to-day is a monument to constructive imagination, a willingness to make and market small amounts, dogged persistence, and the very perfection of salesmanship and operating organization. With but one exception, alizarin, the whole industry must then have seemed as though it would never outgrow the "pot and kettle" stage, that is, manufacture in small units—a "toy" industry, in other words.

In 1913, Germany had twenty-two going concerns making coal-tar dyes; these are the survivors among thirty-nine concerns, of which eleven were abandoned and six were absorbed.

The latest figures available for Germany's export business in normal times are those for 1913; in that year Germany exported 120,000 short tons of dyes having a declared export value of \$51,640,000, or \$430 per ton, or 21.5c. per lb. In the same year Germany exported intermediates to the extent of 22,000 short tons, of a declared export value of \$4,310,000, or \$196 per short ton, or 9.8c. per lb.

In the mass, these are stupendous figures, totaling 142,000 short tons and \$55,950,000, or an average value of \$394 per ton, or 19.5c. per lb. On closer inspection it will be found that for the more than 1200 things that have to be made, this means an average of not more than 118 tons per year, or \$46,625 per year per product for the entire world outside of Germany; at 300 days per year this means on the average not more than 790 lbs., or \$155 per day per product, for the entire world outside of Germany.

The dividends declared and distributed in 1912 by 21 of the German coal-tar dye manufacturers amounted to \$11,600,000. The 1913 dividends were about the same as those for 1912. Of the twenty-two plants of 1913, one declared no dividend and four sustained a loss amounting to about 8 per cent of their capitalization. Per product, these 1912 distributed dividends amount to not more than \$9,700, and these dividends included whatever of profits these concerns made as distributors and makers of their wares, including heavy chemicals, dyes, intermediates, photographic chemicals, synthetic medicinals and pharmaceuticals, explosives, and the like, all inclusive of Germany's own consumption of all these articles. If the German consumption be taken at twice the United States importation in 1913, this makes Ger-

*An address delivered on July 25, 1914, at the Mid-Year Meeting, National Association of Dye and Pigment Manufacturers.

many's total production in 1913 about \$78,000,000; \$11,600,000 in dividends means not more than one dollar in dividends on each \$6.72 of turnover, or not more than 15 per cent on the turnover.

If proper allowance be made for the large individual articles of consumption, the average annual value, output, and profit for the remaining things becomes very much less than above given, and perhaps only 60 per cent of the above average figures, say to 475 lb. or \$90 per day gross per product for all the world outside of Germany.

At \$15,000,000 for the manufacturers' value of all coal-tar dyes consumed in the United States in normal times—and this is a very liberal figure—this means 15c. per year for each of the 100,000,000 inhabitants of this country; for each person in this country to average a consumption of 1c. for each of the present-day 1200 dyes and things needful in making these dyes—i. e., \$12—would take 80 years.

From the point of view of average individual annual tonnages, gross receipts, distributed dividends, or individual personal consumption, there is firm ground for the opinion that even to-day the coal-tar dye industry, big as it is in the mass, is still, in great measure, a "pot and kettle" affair, a "toy" industry, or a "department-store" aggregation of many small units, and that in mercantile reality and in total effect it is just about a "one-nation" business.

In 1913 there were probably not over 40,000 people all told engaged, in the whole world, in the manufacture of coal-tar dyes and of the chemicals needed therefor, apart from making and distilling coal-tar in itself. The entire indigo consumption of the world, which is the largest single item in the whole business, probably can be produced with not more than 1500 men all told. Taking our own total consumption of coal-tar dyes of all kinds as one-seventh of the world's total, 6000 people could reasonably be expected to be the maximum number needed for its production. In 1914, our railroads hauled 1,000,000,000 tons of freight; our dye consumption is about 30,000 tons per year; to make these here would probably not add 60,000 tons to the country's freight haulage, or 0.006 per cent. If we made all and the whole of our own dyes, that would diminish our total national merchandise import business by about 0.5 per cent. Assuming the dividends to be apportioned as above, this would mean about \$1,660,000 of added dividends.

So, from the point of view of added labor, freight haulage, diminution of our foreign business, and added dividends, if we made all our own dyes within the country the project does not seem to be a strikingly alluring one from a national outlook.

Among all the branches of the chemical industry of Germany, the coal-tar dye industry is the greatest of dividend payers, paying ten points more in dividends than any other branch. It sells its products in thirty-three countries outside of Germany, and therefore has its eggs distributed among many different baskets.

In any plans we may make for bringing about our independence of any foreign country for coal-tar dyes, medicinals, and other useful like products, we must take all the foregoing facts and deductions into account, and provide for them and their consequences so far as we can reasonably foresee them.

Why should we be thus independent? In the tariff revision of 1883, dependence upon other countries was avowedly, eagerly and deliberately advocated and accepted, among other reasons given being that we could never build up the coal-tar dye industry here, and that the import duty raised the price of

red-flannel shirts 25c. per dozen and the price of an average-sized rag carpet 3 or 4c. In 1908 there were seventeen New England cotton establishments protesting collectively against any tariff increase, because that would increase the cost of manufacturing colored cotton goods in the United States and the price to the consumer in the United States; and in the case of export trade, an advance in the cost of any of their raw materials adds to their burdens and minimizes their opportunity to compete with foreign cotton manufacturers in foreign markets.

In the 1913 tariff revision, southern cotton mills took substantially the same position. In the record of the hearings on the Hill bill, held Jan. 14 and 15, 1916, some of the seventeen signers of 1908 reversed themselves either in writing or orally. Those who have so reversed themselves represent about one-third of the total labor, power, and textile-machinery capacity of the seventeen, and probably the same proportion of the total capital. Since then others may have reversed themselves, but, if so, that fact has escaped me.

Thus, from 1883 to 1913, coal-tar dyes were regarded as raw materials, and as such they should be free, or taxed but little. Whatever import duty was assessed during that period of time did not in any way encourage or foster an American coal-tar dye industry and did not interfere with our avowed purpose to be dependent upon others in this regard; all this in the face of continued, repeated, and elaborate protests against such a course by those then engaged in making dyes in this country. The probable effect of a European war upon our industries using foreign-made dyes was discussed in July, 1882, as follows: "These goods are made not only in England, but in Germany, and if the worst comes to the worst, and we were cut off from our European supplies, we could fall back on the vegetable dyes that came from South and Central America before aniline dyes were invented."

The 1883 tariff cut closed many of the then existing nine American coal-tar dye plants; to some of the individuals it meant ruin. If, as a result of the present-day cry for re-establishment of this industry a new tariff is enacted and men for that reason engage in this venture, the nation must keep faith and its implied covenant, and not leave these men in the lurch; we must never backslide merely because we then find the actual cost higher than in our present state of mind we believe it will be or think we are prepared to pay. Let us be absolutely clear in our own minds and sure of ourselves. If we decide to go forward—never let us turn back.

Ever since 1883 a specific tax has not been assessed; an advalorem duty and ranging from 25 to 35 per cent, now 30 per cent, and that on a part only, not all dyes made from coal tar. As a matter of fact, we have not had a real domestic coal-tar dye industry—merely an assembling industry; that is about all the tariff can be said to have effected.

In the year 1913, Germany sent us, in round numbers, \$7,300,000 of so-called aniline dyes dutiable at 30 per cent; \$2,800,000 of alizarin and anthracene dyes and indigo, not dutiable; and \$1,086,300 of intermediates, dutiable at 10 per cent. These are the rates of the present Underwood tariff, effective October 3, 1913.

Taking these figures and rates as a basis, the total revenue thus assessable and collectible would amount to \$2,298,632; under the Hill bill provisions this would have been \$6,908,648; and under the Kitchin bill provisions this would amount to \$4,999,084; the increases over the Underwood tariff being for the Hill bill \$4,610,016, and for the Kitchin bill \$2,700,452; that is, where the Hill bill contemplates adding \$1.00 the

Kitchin bill contemplates adding 59c. In other words, where Underwood adds \$1.00 to the export value the Hill bill adds \$3.00 and the Kitchin bill \$2.18, assuming for the purpose of this comparison that the duty imposed will appear entirely as added cost to the consumer, which may or may not be the case.

We know that the Underwood dollar did not create a dye industry. We are led to believe by informed persons, acting upon honor and entirely disinterestedly, that the Hill bill's \$3.00 will probably create a complete self-contained and self-sustaining industry in this country, which will make not only coal-tar dyes and explosives, but also all the many other things obtainable from coal tar and other like materials, and that anything less than that is not likely to lead to any substantial industry. With this view the most experienced domestic coal-tar dye makers agree.

The Kitchin bill proceeds from the admission and premise that the Underwood and all like dollars created no industry to the conclusion that \$2.18 will create a complete self-contained and self-sustaining industry in this country. We know that the Underwood dollar, and all similar preceding dollars, might just as well have been thrown into the sea for all the real domestic industry they created; the Kitchin bill's \$2.18 may merely be throwing good money after bad; we are told that the Hill bill's \$3.00 may be the same, but not probably. That is the dollars-and-cents view of the proposed legislation at Washington.

Again, we are similarly told that protection in order to protect this industry must protect it all the way round. The Hill bill does that; the Kitchin bill does not. If you were building a high board fence round your vegetable garden to keep your neighbors' chickens out, would you build three-quarters of the fence so that it went well into the ground, and leave the other quarter 3 ft. from the ground, on the theory that the chickens would not find this weak spot in your fence? In exempting anthracene, alizarin and indigo dyes and indigo from the surtax, that is precisely the theory on which the Kitchin bill proceeds, and it offers, at the suspended portion of the fence, an added bait for the chickens, by threatening to remove the surtax unless 60 per cent of the value of our total consumption is produced in this country within five years. That is about the same as if, in addition to building the fence as just described, you industriously sprinkled a lot of "chicken feed" so that it leads directly to this hole in your fence. That is the strategy of the Kitchin bill.

How shall the domestic value be computed? Shall the foreigner be allowed to add to his invoice value, duty, surtax, and any other usual charges? If so, he is given a considerable advantage over and beyond the 27 per cent start the Kitchin bill proposes to give him; this start may become 35 per cent and all the foreigners have to do would be less than 5 per cent additional work.

The Kitchin bill and the Hill bill each proceeds from the fundamental proposition that unless we protect the coal-tar dye and chemical industry in this country we are not going to have any such industry. That proposition may therefore be accepted as being true, conclusively established and the permanent consensus of public opinion; since it is indorsed by both the Democratic and Republican parties, free trade and protectionist alike. The only reasonable conclusion from this is that both political parties and the public each and all stand affirmatively committed to the national need of a coal-tar chemical industry in this country that shall be permanent, complete, self-sustaining, independent and fully capable of self-development; anything less than that would be a mere makeshift and a Dead Sea apple.

In the case of a given typical example of a cheap and

widely used coal-tar dye the Hill bill contemplates a net added protection ranging from 3.44c. to 2.95c. per lb.; the Kitchin bill contemplates a net added protection ranging from 2.08c. to 1.59c. per lb.; the American dye makers in 1908 wanted a net added protection of 3c. per lb. for that general class of dyes. The Hill bill gives the dye maker what he says he needs; the Kitchin bill does not. If we *really* want an American coal-tar dye industry and all it brings and may bring with it, why should we thus haggle? The reason seems to be that we fear that the Hill bill rates will create a set of "tariff robbers," and the assumption is that the Kitchin bill will not. Once we have a domestic dye industry we ought to be able to handle the "tariff robber" question on its merits, or are we so to confess that the only way we can check "tariff robbers" is not to have an industry?

Further, the Kitchin bill thinks that this protection might cost as much as \$2,700,000 per year; the Hill bill thinks this cost to be \$4,610,000 per year—either one a tidy sum, even for this nation and one which we should not light-heartedly incur.

Now, *why* should we have it? Surely not to add 6,000 people to our laboring population; this would be \$450 per year per person under the Kitchin bill and \$768 under the Hill bill. Surely not for 60,000 tons additional freight haulage, for this would be per ton of freight \$45 under the Kitchin bill and \$77 under the Hill bill; nor would it be good business to pay either sum so that certain stockholders could get \$1,660,000 per year in dividends. It cannot be a dollars-and-cents reason in this direction.

The Hill bill and the Kitchin bill were both introduced into Congress because of the insistence of dye-using interests that something be done to relieve the dye shortage and not at the request of dye-makers. These same interests for thirty years had kept down the duty on dyes, and were almost solely responsible for the disastrous tariff cut of 1883; the dye-using interests therefore have almost complete control of the dye-tariff policy of this country, and the dye and chemical making interests have no such control—not even a reasonable hearing. Under these circumstances it is reasonably clear that the dye-using interests can have any duty that may now be added removed at their pleasure. It is not sound, national policy to attempt to build up an industry in this country by protective legislation when the profits in that industry for some time will be dependent upon such protection and then have the power of altering that protective policy lodged exclusively in the hands of the customers of that industry to be exercised at their pleasure and in their interests only. When the situation is relieved why should they not have the duty removed? If they decided on that course the dye and chemical makers might be just as helpless to prevent it as they were in 1882 and continued to be down to 1913 and are, in fact, to-day.

It is true that the dye users also insist that arrangements shall be made so that such shortage cannot recur; but might they not brush that aside just as in 1882?

The *Journal of Commerce* of New York, on April 24, 1916, said:

"In the meantime dyes have been offered and sold here at fabulous prices in quantities palpably sufficient to keep all the largest textile plants moving. Somewhere and somehow supplies of dyes have been secured, for never before in the history of the United States textile industries have plants been run so full as they have been in the past six months, whether plants for printing, finishing and dyeing."

So that, from about the end of October, 1915, there has been no scarcity of dyes—provided you paid the price. Is that a "famine" or just a "corner"?

Had cotton not dropped violently in price in August, 1914, or, if you gentlemen had then been willing to pay 15c. for 6-cent cotton, there would not have been any such prompt demand for dyestuff-independence; we would probably not have heard much, if anything, about independence until fully a year later, if then. By so widely and publicly using the dye-stuff situation to offset the demoralized cotton market the cotton manufacturers simply invited others to come in and "corner" the dyes, which seems to have been efficiently done.

In now demanding that this country should never have been dependent upon others and that the dye-shortage, famine or corner, whatever you may choose to call it, should not have been permitted to exist, the dye-using interests are merely complaining against the logical, clearly foreseeable, but deliberately ignored results of their own deliberate and concerted acts.

To engage upon business merely to relieve a famine, real or artificial, is not attractive to anyone; to enter upon it to establish it upon a sound permanent basis is quite another thing. Frankly, all that the dye-using interests can safely be counted upon for is to want to relieve the situation, and they do not care how it is relieved—beyond that all is uncertainty, with the chances in favor of their successfully abandoning their desire for a strong domestic industry so soon as they can see reasonably clearly ahead for themselves, regardless of what the dye and chemical makers may think of the then existing conditions.

Legislation to foster this industry can be no more lasting than the reason for its existence. None of the reasons so far discussed can truthfully be said to promise sufficiently long life to achieve that result. They have all been successfully used in the past to prevent such protection; they are now urged to create such protection; there is no reason to believe that they will not revert to their former purpose at the very first opportunity, and that will no doubt come long before the industry is safely established.

These reasons touch relatively few of us. The question of having at all times equipment in this country and men capable to operate it to produce means of national defense, *i.e.*, high explosives, is one which promises to affect all of us. Now, what could a complete, self-contained and self-sustaining domestic dye industry making our total requirements of dyes so contribute? The most we could reasonably expect from it is that in a comparatively short time, say, a month or less, it could turn out 100 tons high explosive per day and could train enough chemists, superintendents, foremen and workmen fast enough properly to operate additional high-explosive-making plants as erected. In the past eighteen or twenty months we have learned, with every possible stimulus, to build from the ground up plants capable of making 80 tons of picric acid per day. How much TNT is made daily is not known to me with any certainty. From that point of view this contribution seems reasonably worth while. If we make 60 per cent of our requirements we very likely would make 60 tons in place of the 100 tons high explosive per day.

The massed coast artillery of our Atlantic and Pacific seaboard has to-day such a capacity of firing projectiles that if 5 per cent of the weight of those projectiles were high explosive, 100 tons high explosive, or one day's output, would last seven minutes. On the same basis, assumed the high-explosive producing capacity of the German coal-tar industry, as it existed just before the war, would last fifty minutes, or perhaps an hour.

Is it worth our while to have such a dormant capacity in this country? In a month we could then reasonably expect to be where otherwise we might not be much under a year? I think so.

If the final answer to that question be an equivocal "yes," and our army and navy officials are the only persons to answer that question in a way that would surely have the confidence of the public, then we have a reason for this special protective legislation that would be far more stable and far less subject to change than any other reason yet given. Such legislation would not be repealed nor altered for trade reasons alone; it would not be repealed until the coal-tar dye industry were really firmly established and we really did have this dormant capacity firmly under our own control. Surely we cannot be so impotent as a people, that we cannot devise ways and means successfully to resist "tariff robbers" and prevent their exploiting us under this kind of a cloak!

The same attitude should be taken if the answer be anything less than an unequivocal "no." In case of doubt play safe. It is better to be safe than sorry.

I have devoted so much time to a consideration of pending Federal legislation and to the precise location of the exact cause of all our dyestuff troubles because the future of the coal-tar dye industry in this country depends upon what and why legislation is enacted. It is no time for half-hearted measures. Either we have the substantial whole of the industry or we will have nothing of value in time of stress.

There is no reasonable question as to the wonderful expansion of coal tar and allied chemistry in the future. Fifty years ago no one would or could have dreamed of an industry of its present day magnitude—an industry that underlies so much of our textile, leather, printing, decorative and other industries; that is such a fundamental part of the great photographic industry; that provides remedies and medicines that reach to every hospital and almost every sickbed in the civilized world and adds to our comfort and well-being in such a multitude of directions as this industry does, and which also supplies so much and so many things to national defense. The best of these have not yet been discovered. There is much room for improvement. Just think of the advance in these lines during the past twenty years. Fifty, even twenty, years from now this combined industry may have grown so that its present permeation of the industrial life of nations will appear as a dwarf by comparison with its then influence.

Had we had a going dye industry in this country at the end of the 90's or early this century there is every reason to believe that we, too, would have been successful makers of the so-called vat dyes that make the wonderfully fast modern shades and would have had a substantial share in the making of all the other dyes and their intermediates and progenies.

The longer we delay getting this industry the more difficult the task will become. Shall we continue to sit by, let others do the work and reap the benefit and continue to be dependent upon others for all these things which are bound to become more numerous and more ramified than ever? There is no question that we can, if we will, make just as good qualities as anyone. We cannot do it unless we have the opportunity to acquire the experience. Shall we continue to be denied the opportunity, or does the nation want these things and actually want them earnestly enough to face the situation and pay the price without quibble and without haggle?

Great as has been our domestic progress in the past two years we cannot hope to keep it all without substantial economic help; to think that we will lose it all even without added help has no foundation in reason. Without help, and real help at that, we will continue to have, in normal times, an industry which is far from complete, and self-sustaining and self-developing and

bound to be a disappointment in time of stress and trial.

Now, which shall it be? The Hill bill, with reasonable certainty of success, or the Kitchin bill, with far less reasonable chance for success? The difference between the two may very well be the difference between substantial success and substantial failure. The differences in cost of finished fabric cannot be great—in most cases far from being large enough to pass along. In those few cases where the added cost turns out to be greater than can be borne they can be taken care of otherwise, and if necessary by needful tariff help. Certainly the difference in cost of finished fabric between the Hill bill and the Kitchin bill can hardly ever be large enough to pass along.

My own view is this: If the country is really honest and sincere in its loud and prolonged clamor for independence in this regard, now is the time to prove it by deeds. Plain, ordinary square-dealing and horse-sense clearly and imperatively demand the prompt enactment of the Hill bill rates, under which it will be none too easy sledding. The Hill bill rates are those that domestic dye-makers say are absolutely necessary to achieve this independence.

The dye users from 1882 to 1913 have deliberately and successfully played right into the hands of foreign dye-makers and against domestic dye-makers, and there is every reason to believe that they have not yet entirely overcome that habit. The Kitchin bill is the Hill bill pared down, cut down, and ham-strung, solely in the interest of dye users. Such quibbling, haggling and cheese-paring do not square with common sense, nor sincerity nor with fair-dealing toward the dye-makers who will have to carry the load. Even if, in years to come, the Hill bill should allow the existence of "tariff robbers" we can cross that bridge when we get to it.

The first thing to do is to get this industry; we can then take care of "tariff robbers," if and when there are any, if we want to.

If we choose the Kitchin bill and success should not attend it we will have lost just so much time and effort and will merely have shown again and for the sixth time that the dye-using interests cannot successfully prescribe tariff rates for the dye-makers. If we choose the Hill bill we will be giving the dye-makers their first real chance at tariff-shaping and also that which they say will enable them to create the complete and independent industry in all its substantial ramifications. If they then fail to create this industry it will be because the very best conclusion they could draw from the past failed to meet the then situation, and we will be better able to make the next step for success.

There is no less chance of encouraging rapacity on the part of the dye-makers under the Kitchin bill, should success attend it, than under the Hill bill should it be successful.

In summary, then, the coal-tar dye industry of the present has grown from obscure beginnings of little real world-wide promise to an industry that is of very wide ramifications in almost every phase of national and international commerce and industry. Experience in the past has shown that in order to get a foothold and develop in this country it must be aided substantially. We have had only an assembling industry. At present we have made great progress much of which will remain with us no matter if the present tariff be changed or not, but it will be in essence an assembling industry still. The future of the coal-tar chemical and allied industries is brighter and fuller of promise than ever. Its future in this country lies in our own hands, to make or to mar. Which will we do?

New York Meeting American Chemical Society

A meeting of the American Chemical Society will be held in New York City Sept. 25 to 30, inclusive, simultaneously with the Second National Exposition of Chemical Industries.

The first general meeting is to be held on Tuesday morning, and on Tuesday afternoon it is hoped to have a public meeting in the large hall of the City College with addresses by prominent men bearing upon "Chemistry and the National Welfare." On Tuesday evening a general "get-together" meeting or smoker will be held by the New York Section complimentary to the parent society, to which visiting chemists will be invited. On Thursday evening the American Electrochemical Society will give a smoker to which the members of the American Chemical Society will be invited, and on Friday evening a subscription banquet will be held.

Meetings divisions will be held on Wednesday, Thursday, Friday and Saturday mornings. One of the special features of the meeting will be general conferences on special subjects in which the chemists of the country are now interested. The idea of these conferences is to have some important topics such as Glassware and Porcelain; Steel Alloy Metals; Paper and Its Utilization; Oils and Motor Fuels; Convertibility of Plant; Medicinal Chemicals; Dyestuffs and Their Relation to Munition Factories; Industrial Alcohol, Acetone and Formic Acid. The discussion is to be started by some well-known specialists in these lines. No special program is planned for these conferences, but it is believed that chemists interested in these various lines will get together and many interesting points will be brought out which will be of mutual interest. The topics for these conferences have not yet been determined upon and suggestions are desired from members of the society. These suggestions will all be placed before the program committee and some six or eight topics selected therefrom. It is anticipated that two conferences will be in session each afternoon at the same time, one in the lecture hall of the Chemists' Club and one in the Grand Central Palace, where the Second National Exposition of Chemical Industries will take place.

The president's address will be one of the general papers at the public meeting on Tuesday.

The Divisions of Biological Chemistry, Physical Chemistry and Industrial Chemistry will hold a joint symposium on colloids on Wednesday and Thursday mornings. On Wednesday morning the symposium will be of a theoretical nature, in which the Industrial Division will not take part. On Thursday morning the symposium will be composed of industrial applications to colloid chemistry.

New York Meeting American Electrochemical Society

The thirtieth general meeting of the American Electrochemical Society which will be held in New York City Sept. 28 to 30 inclusive, in conjunction with the Second National Exposition of Chemical Industries, promises to be a most interesting and an exceedingly valuable meeting to attend. On Tuesday evening, Sept. 26, a general reception will be held at the Hotel Astor to which members of the American Electrochemical Society are invited. On Wednesday evening a general reception and registration will be held at the exposition. On Thursday morning will be held the "Made in America" technical session; on Thursday evening a complimentary smoker; on Friday morning a technical session; on Friday evening a joint banquet at the Waldorf-Astoria with the American Chemical Society. On Saturday an excursion may possibly be held.

The Thermal Decomposition of the Aliphatic Hydrocarbon Derivatives of Naphthalene

BY GUSTAV EGLOFF

The thermal decomposition of the pure aromatic hydrocarbons, benzene, toluene, xylene, cymene, naphthalene and anthracene has been studied.¹ The course of reaction due to temperature and pressure changes was found to be as follows: Higher homologs of benzene, lower homologs of benzene, benzene, diphenyl, naphthalene, anthracene, carbon and gas. In the following paper the aliphatic derivatives of naphthalene have been subjected to pressure and temperature conditions to form benzene and toluene.

SCOPE OF THE PRESENT INVESTIGATION

A tar oil resulting from the destructive distillation of coal contains compounds of the aliphatic and aromatic hydrocarbons. Tar acids and bases with naphthalene and anthracene are present in the tar oil. An earlier communication² showed that a tar oil did not decompose readily to form benzene and toluene. It has been found that naphthalene³ and anthracene under thermal and pressure conditions went mainly to gas and carbon, with no appreciable benzene or toluene formation. This did not preclude the possibility of benzene and toluene formation from the tar oil in quantity after extracting tar acids, bases, naphthalene and anthracene, leaving an oil chiefly composed of aliphatic derivatives of naphthalene.⁴ The removal of tar acids, bases, naphthalene and anthracene was necessary if benzene and toluene were to be formed appreciably.

DERIVATION OF THE OIL USED

The oil used was one derived from the thermal decomposition of coal, and is commonly known as a tar oil. This tar oil contained tar acids, bases, naphthalene, anthracene and aliphatic compounds of naphthalene. Table I covers the distillation analysis of the original tar oil.

TABLE I—DISTILLATION ANALYSIS OF ORIGINAL TAR OIL
Specific gravity, 1.007-15.5 deg. C.

Temperature, Deg. C.	Per Cent by Volume	Specific Gravity
125 to 150	4.0	0.860
150 to 200	5.5	0.945
200 to 250	47.0	0.975
250 to 300	26.5	1.005
300 to 350	9.5	1.037
Residue	7.0	
Loss	0.5	

The bases present in the tar oil were removed by treatment with sulphuric acid in the usual manner. The tar acids of the phenol, cresol type were extracted by

TABLE II—ANALYSIS AFTER REMOVAL OF BASES AND TAR ACIDS
Specific gravity, 1.005/15.5 deg. C.

Temperature, Deg. C.	Per Cent by Volume	Specific Gravity
125 to 150	8.4	0.930
150 to 200	42.0	0.999
200 to 250	12.0	1.025
250 to 300	5.0	
300 to 350	12.0	
Residue	0.6	
Loss		

the use of a sodium hydroxide solution. The oil, after bases, tar acid removal analysed as shown in Table II.

After removal of tar acids and bases the oil was

cooled with a salt-ice mixture so as to remove naphthalene and anthracene present. The oil after naphthalene and anthracene extraction gave the distillation analysis of Table III.

TABLE III—ANALYSIS OF OIL AFTER REMOVAL OF NAPHTHALENE AND ANTHRACENE
Specific gravity, 1.000/15.5 deg. C.

Temperature, Deg. C.	Per Cent by Volume	Specific Gravity
125 to 150	8.8	0.930
150 to 200	75.0	0.995
200 to 250	15.0	0.999
250 to 300	3.1	0.998
Loss	0.6	

This oil contained mainly alkyl and alkene derivatives of naphthalene.

EXPERIMENTAL PROCEDURE

The method of thermolizing the oil has been covered by Whitaker and Rittman.⁵ It consisted essentially of an electrically heated tube through which the oil was passed at a definite rate.⁶

The oil was cracked under conditions of pressure and temperature, which gave a liquid widely different in composition from the original. It was analysed for its benzene and toluene content by the specific gravity—distillation method⁷ and also by nitration. The nitro derivatives were determined as the mononitrobenzene and dinitrotoluene. The carbon formed was determined approximately by scraping it from the walls of the cracking tube and by filtering the suspended carbon in the thermolized oil.

The experiments were conducted at temperatures 600° C., 650° C. and 700° C., with pressures ranging from one to fourteen atmospheres.

EXPERIMENTAL DATA

TABLE IV—EFFECT OF TEMPERATURE AND PRESSURE ON THE PER CENT RECOVERED OIL AND THE PER CENT OF CARBON FORMATION

Temperature, Deg. C.	Pressure, Atmospheres	Per Cent of Recovered Oil by Volume	Per Cent of Carbon by Weight
600	11	68.5	8.3
650	1	75.0	1.5
650	11	50.0	5.0
650	14	45.0	10.0
700	11	33.6	29.0

TABLE V—EFFECT OF TEMPERATURE AND PRESSURE ON THE PER CENT BENZENE AND TOLUENE IN THE RECOVERED OIL

Temperature, Deg. C.	Pressure, Atmospheres	Per Cent Benzene	Per Cent Toluene
600	11	1.5	3.5
650	1	1.2	0.7
650	11	6.0	4.0
650	14	7.0	3.9
700	11	8.5	3.9

TABLE VI—EFFECT OF TEMPERATURE AND PRESSURE ON THE PER CENT BENZENE AND TOLUENE ON THE BASIS OF ORIGINAL OIL USED

Temperature, Deg. C.	Pressure, Atmospheres	Per Cent Benzene	Per Cent Toluene
600	11	1.0	2.0
650	1	0.9	0.7
650	11	3.0	2.0
650	14	2.8	1.8
700	11	2.8	1.3

¹Rittman, Byron and Egloff, *Jour. Ind. Eng. Chem.* 7, 1019, 1915.

²Rittman and Egloff, *MET. AND CHEM. ENG.* 14, 15, 1916.

³Loc. cit.

⁴Schulze, *Berichte* 17, 842, 1884. Emmert and Reingruber, *Annalen*, 206, 367, 1880. Lunge, *Coal Tar and Ammonia*, 1909.

⁵Whitaker and Rittman, *Jour. Ind. Eng. Chem.* 6, 383 and 452, 1914.

⁶Egloff and Twomey, *Jour. Phys. Chem.* 20, 121, 1916.

⁷Rittman, Twomey and Egloff, *MET. AND CHEM. ENG.* 14, 620, 1915.

DISCUSSION OF EXPERIMENTAL DATA

A. The effect of temperature and pressure on the per cent of recovered oil and the per cent of carbon formation.

a. At constant pressure of eleven atmospheres a change of temperature from 650° to 700° C. decreased the per cent of recovered oil from 50 to 33.6 per cent, a difference of 16.4 per cent in the amount of decomposition. At a pressure of fourteen atmospheres and increasing the temperature 50° C. the decrease in the per cent of recovered oil was 23.6. This indicates that greater decomposition takes place at a higher pressure and lower temperature.

b. At constant temperature of 650° C. a change of pressure from one to fourteen atmospheres gave a greatly increased velocity of decomposition of the original oil. The yield of recovered oil decreased 30 per cent upon increasing the pressure from one to fourteen atmospheres.

c. The formation of carbon increases with increase of temperature and pressure. In this series of experiments temperature had a greater effect upon the carbon formation than pressure. At constant pressure of eleven atmospheres a temperature difference of 50° C. increased the carbon yield from 5 to 29 per cent. At constant temperature of 650° C. an increase of pressure from one to fourteen atmospheres, the per cent of carbon ranged between 1.5 and 10 per cent. Higher temperatures and pressures would have yielded the ultimate products—carbon and gas.

B. The effect of temperature and pressure on the per cent of benzene and toluene in the recovered oil.

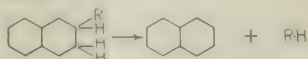
The yield of benzene in the recovered oil increases with increase of temperature, at pressures eleven and fourteen atmospheres. At eleven atmospheres a change of temperature from 650° to 700° C. reduced the per cent of toluene from 4 to 3.9. At constant temperature of 650° C. increase of pressure increased the benzene content, whereas, the toluene reached a maximum and then decreased. Toluene formation is favored by lower pressure and benzene by higher.

C. The effect of temperature and pressure on the per cent of benzene and toluene formation on the basis of original oil used.

At fourteen atmospheres a change of 50° C. increased the yield of benzene from 1 to 3.2 per cent. Under similar conditions the toluene decreased from 2 to 1.8 per cent. A change from 650° to 700° C. and eleven atmospheres decreased the benzene and toluene yield. At constant temperature of 650° C. increase of pressure is favorable for benzene formation but not for toluene. A temperature of 650° C. and fourteen atmospheres is most favorable for benzene, whereas the same temperature and eleven atmospheres gives maximum toluene formation.

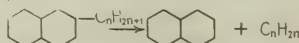
THE MECHANISM OF REACTION

Jones and Wheeler¹ in distilling coal at a temperature below the formation of hydrogen have found aromatic hydrocarbons present in the distillate. In accounting for the presence of aromatic hydrocarbons of the type of naphthalene they assumed the course of the reaction to be as follows:



Brooks² and coworkers account for the formation of

naphthalene by assuming that the naphthalene radical must be present. This assumption is deduced inferentially from decomposing a mixture of phenyl paraffins forming benzene, toluene and unsaturated hydrocarbons. They assume the course of the reaction to be as follows:



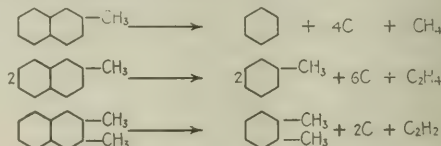
Jones³ found that under a temperature of 420° C. dihydronaphthalene gave a gas composed mainly of hydrogen and traces of higher olefins and ethylene. Decomposition of tetrahydronaphthalene at a temperature of 530° C. gave in the gas:

	Per Cent by Volume
Benzene and higher olefins	3.2
Ethylene	3.3
Hydrogen	80.5
Methane	9.2
Ethane	4.0

No analysis of liquid, if any resulted, was given.

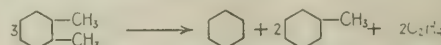
In the thermal and pressure decomposition of aliphatic derivatives of naphthalene, benzene and toluene being formed the following mechanism of reaction may be assumed as having taken place. Though one must bear in mind that in complex reactions of hydrocarbon mixtures, no one reaction can be looked upon as taking place by itself, secondary and tertiary reactions must take place paralleling the primary.

When Jones³ heated di and tetrahydronaphthalene the products in the gas were benzene, ethylene, hydrogen, methane and ethane. Now the starting oil used in this investigation contained monomethyl and dimethyl naphthalenes⁴ with higher aliphatic compounds of naphthalene. If one heated monomethyl and dimethyl naphthalene the reaction products can reasonably be expected to take the following course:

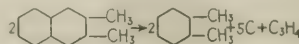


Similar reactions would very likely follow using higher alkyl and alkene compounds of naphthalene.

Secondary reactions taking place at the temperature and pressure to which the oil was subjected would decompose the xylene, forming benzene and toluene. The decomposition of xylene giving benzene and toluene has been determined experimentally.⁵



Another direction of decomposing dimethylnaphthalene would be in the formation of allylene.



From the researches of Berthelot⁶ and other workers in the field of acetylene, it is certain that acetylene polymerizes, forming benzene and other aromatic hydrocarbons.

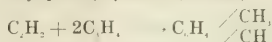
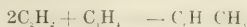


Jacobsen⁷ assumes the higher homolog of acetylene,

¹Jones and Wheeler, *Proc. Chem. Soc.*, 19, 267, 1911.
²Brooks and Humphrey, *Proc. Am. Chem. Soc.*, 28, 296, 1915.
³Brooks, Bacon, Padgett and Humphrey, *Jour. Ind. Eng. Chem.*, 7, 180, 1915. *Brooks Jour. Fueling Inst.*, 6, 6, 1915.

⁴Jones, *Jour. Chem. Soc.*, 107, 1582, 1915.
⁵Reingruber, *Annalen*, 106, 367, 1884. Schulze, *Berichte*, 17, 842, 1884.
⁶Bertlettman, Byron and Egloff, *Jour. Ind. Eng. Chem.*, 7, 1019, 1915.
⁷Jacobsen, *Berichte*, 10, 852, 1877.
⁸Berthelot, *Ann. Chim. Phys.*, 9, 445, 1886; 12, 52, 1887; 16, 143, 1869. *Carbures D'Hydrogene*, 1851-1901 (Collected Works). Anschutz, *Berichte*, 11, 1215, 1878. Lowes, *Trans. Inst. Gas Eng.*, 10, 111, 1900. Meyer, *Berichte*, 45, 1609, 1912.

allylene to take part in the synthesis of toluene and xylenes.



From the above assumed mechanism of reaction, part of which is based upon experimental evidence, the formation of benzene and toluene may take place either by—

1. Direct decomposition of methylnaphthalenes.
 2. Formation of xylenes and subsequent decomposition.
 3. By synthesis from acetylene and allylene.
- In all likelihood the three reactions take place in successive steps, or simultaneously.

SUMMARY

1. An oil mainly composed of aliphatic derivatives of naphthalene derived from coal tar was subjected to the following temperature conditions, 600° C., 650° C. and 700° C. and pressures of one, eleven and fourteen atmospheres.

2. Temperature and pressure have a marked effect upon the decomposition of the original oil. Temperature favors decomposition to a greater extent than pressure.

3. The formation of carbon increased with increase of temperature and pressure. Twenty-nine per cent of the original oil went to carbon, at a temperature of 700° C. and fourteen atmospheres. The reaction of decomposition tended toward the ultimate products—gas and carbon.

4. The yield of benzene and toluene increased with temperature in the recovered oil within the limits of these experiments. Toluene formation increased to a maximum and then decreased as the temperature and pressure increased.

5. The maximum condition of 3.2 per cent of benzene formation on basis of original oil used was at 650° C. and fourteen atmospheres pressure. Two per cent of toluene was formed at 600° C. and fourteen atmospheres; and 650° C. and eleven atmospheres.

6. The mechanism of reaction has been assumed to take place, which is partially based upon experimental evidence, forming benzene and toluene—

1. Direct decomposition of methylnaphthalenes.
 2. Formation of xylenes and subsequent decomposition.
 3. By synthesis of acetylene and allylene.
- The three reactions take place either in successive steps or simultaneously.

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National Fertilizer Convention

The twenty-third annual convention of the National Fertilizer Association was held at Hot Springs, Va., July 10 to 14. It was a most enthusiastic gathering, despite unfavorable conditions in the fertilizer industry during the past year, due to the cessation of imports. About 250 members were in attendance. The business sessions were held in the mornings, with the afternoons and evenings devoted to golf, riding and other entertainment features. A banquet was held Wednesday evening at which Hon. Theodore E. Burton and ex-Senator Chauncey M. Depew were the speakers. Great interest was shown in the educational work carried on by the Association during the last five years. Horace Bowker, secretary of the American Agricultural Chemical Company was elected president for the coming year; W. D. Huntington, vice-president of the Davison Chemical Company, elected vice-president; Irvin Wuichet re-elected treasurer, and W. G. Sadler re-elected secretary.

Blast Furnace Irregularities and Their Treatment—II

BY J. E. JOHNSON, JR.

Water Troubles

Water troubles are of two separate and distinct kinds, though one kind may, and generally does, lead to the other. These kinds are, first, an interruption either partial or complete in the cooling-water supply of the furnace; second, penetration of the water into the hearth of the furnace. This may be due, in a broad way, either to the failure of one or more cooling members, tuyeres, coolers, cooling plate and the like, or more rarely to the infiltration of water through cracks in the bosh packet or hearth jacket, or into the brick direct where it is not protected by metal jackets.

Failure of the water supply may occur in many ways: Failure of pumping plant, the bursting of the supply main, and as regards the individual cooling members, by the plugging up of the supply cocks with vegetable matter, fish or other foreign substance in the water.

The troubles are of two kinds—partial and complete. The effects of the two cases are very different. If the failure is complete, all the more important cooling members are almost certain to be burnt before the furnace can be cast and stopped. This is a calamity of the first order, and whether the failed members can be restored and the furnace put back into operation after the water supply is restored or must be blown out for repairs, depends upon the conditions of the individual case.

COMPLETE FAILURES OF THE MAIN WATER SUPPLY

These are among the most terrible of the accidents which can take place around the blast furnace, even if the fully supply be restored within a few minutes. The life of the furnace itself depends upon the existence of water cooling, always for the tuyeres, coolers, cinder notch and cinder cooler, and usually for many other cooling members, particularly the cooling plates in the bosh wall, when that type of construction is used. The failure of water on these for more than a second or two is generally sufficient to cause their destruction. The water remaining in them below the drainage level is very often sufficient to cause an explosion when they are burnt, and the small amount drained in from the water system is always enough to chill the furnace to some degree; if there is a small amount of water left flowing in the system, this is sufficient in a few minutes to put the furnace out of business for days.

When the water supply is restored after a brief interruption there are still great difficulties to be overcome. If it is known that any member has failed completely, the only thing to do is to shut the water off from it, but the solution of the problem is not generally as simple as this. It is almost out of the question to shut the water off from an active cooling member like a tuyere when the blast is still on the furnace, because under such conditions the member cut off is burnt out completely in a few minutes, and under the very best conditions the blast blows out through the opening with terribly destructive effect. In most cases this is accompanied by a heavy flow of cinder, and not infrequently by iron with its terrific cutting power, which is likely to lead to the destruction of other cooling members as well as cutting the exterior part of the furnace construction, the columns, hearth and bosh jackets, etc. If the first piece to go is a tuyere, such a sequence leads to the destruction of the cooler also in many instances. If, therefore, a number of cooling parts have failed under such conditions, it is absolutely essential to cast the furnace instantly; then the blast

can be taken off and the water can be shut off from the failed members without danger of serious consequences.

PARTIAL FAILURE OF MAIN SUPPLY

When only partial failure of the main water supply occurs, much can be done to reduce the seriousness of the resulting damage. The furnace must be cast and stopped without regard to any consideration except speed. The blast should be taken off the first instant it is safe to do so without filling the tuyeres with cinder. This does not reduce the temperature of the different zones of the furnace instantly, but it does reduce to zero the velocity of the gas currents, and this is of greater importance in diminishing the destructive power than reduction in temperature itself.

Generally the upper cooling members, particularly those above the mantle, if there are any, lose their water supply first as the head on the system falls. As described under "Construction," if these are made of iron the water circulation can generally be restored to them even after quite a long stoppage, but if they are bronze they generally melt and must either be replaced or else filled up with grout to form a physical support for the lining resting on them and to prevent the gas from burning out through them.

While the loss of these members is extremely serious, its effects are not so immediate or so disastrous as the loss of the cooling members in the hearth and bosh of the furnace. Here the tuyeres and coolers are subjected to the severest conditions by far, and if there be a partial supply of water remaining it should be diverted to them at the expense of all the other cooling members.

I have been through three partial failures of the main water supply, in each case from the failure of a fitting on the line, the breakage of which permitted the escape of the large part of the water supply and the diminution of the head on the system to the point where it was no longer sufficient to supply all the cooling members. In each case we escaped very serious damage by the same general course of procedure. The great difficulty in each case was to restore the broken fitting without shutting off the water supply completely, so causing the failure of all the members even when the furnace was stopped.

There should always be, and generally is, at every plant, a high-pressure water supply of relatively limited volume for fire service and the like, and this we had in each of the three cases mentioned, but in none of them was this supply nearly adequate for the cooling system of the furnace as a whole. In one case the supply was so limited that after the furnace was stopped the tuyeres were pulled out and the noses of the coolers packed with clay. This eliminated the tuyeres from consideration and permitted us to use the scanty supply available for the coolers and the lower rows of cooling plates. These we connected up by hose lines with the high-pressure supply and by driving the latter for all it was worth we were able to force enough water to these members to preserve them under shut-down conditions, though they would not have lasted 10 seconds with the blast on.

While this emergency supply was being connected, everything possible that could be done in advance toward replacing the failed fitting was made ready. Finally, when all was ready, the emergency supply was connected up, the regular supply shut off and the failed fitting removed, the new one was then inserted, the pipe coupled up and the regular supply turned on. In one case things were getting so hot with only the emergency supply that as soon as the new fitting was in place, and before any gasket was inserted in the

joint, we turned on the regular supply for a few minutes in that condition. It made a lively spray from the open joint, but sent enough cool water into the cooling members to give us a few minutes' grace, and in that time we slipped in the gasket and tightened up the bolts and then the regular supply was put on to stay.

It is on account of these experiences that I hold to the belief expressed in the chapter on furnace construction that two separate supply mains should be provided, each connected independently with the circular main around the furnace by a non-return valve set as closely to the circle main as possible. Then in the case of the failure of either main the other will continue to supply the furnace and no difficulty will arise from inability to shut off the break, because it is *between* the valve and the main, as happened in some of these cases.

OBSTRUCTIONS IN PIPES

One of the serious difficulties in a water supply liable to flood conditions is the accumulation of fine twigs, etc., which pass the main screen at the pump intake. These, combined with the silt and mud in the water, make it almost impossible to keep the circulation going on the most exposed cooling parts, especially the tuyeres. Because if the full water supply is diminished even a little, steam is generated and the pressure of this forces the water back into the supply pipe; the discharge then begins kicking and if quick action be not taken the loss of the tuyere is certain to follow within a minute or two, if not within a few seconds.

The best remedy for this difficulty is to have a strainer in the supply line, very much finer than the screen over the main inlet. This must be in duplicate and arranged for quick removal and cleaning; twin strainers are regularly built for this service and some of them are excellent in design and construction. The use of those when supplemented by extra care in times of flood water will cure the worst of the troubles from this source.

In order to guard further against this form of failure, the feed cocks from the circular water main are always made three-way and so arranged that by turning the plug into one position a wire can be run up through the bore of the cock into the supply main and the obstructing particle removed. In cases where this does not suffice to clear the pipe the three-way feature of the cock is useful because by turning it into position to connect the third or spare opening with the supply pipe and connecting a pressure hose onto what is ordinarily the discharge of the cooling member, the water current through that member can be reversed and most obstructions are removed by that treatment.

Certain waters carry in suspension vegetable matters such as the waste of paper mills, and these build up like fish scales in the pipes, in time obstructing them very seriously if not removed. They cannot be flushed out, because like fish scales they lie flat down-stream, but by a strong reversed current they can be ripped off in a few minutes and the pipe entirely cleared.

When the same cooling water is used over and over vegetable growths are apt to occur, much like the green slime seen on stagnant ponds, and these are very troublesome. They can generally be cured by the use of a very small amount of copper sulphate in the water.

EFFECT OF WATER UPON FURNACE OPERATION

In the article on thermal principles of the blast furnace, the subject of moisture in the blast has been treated at some length and the reason for the ruinous effect of water on the operation of the furnace has

been explained. It is well, however, to revert to the subject here and to emphasize its vital importance from the purely operating point of view, as distinguished from what might be considered by some the theoretical.

Let us assume a blast temperature of 1200 deg. and a critical temperature of 2750 deg. Fahr., then referring to our diagram of hearth heat available, it will be seen that the hearth heat per pound of fuel with no moisture is 1845 B.t.u. With $\frac{1}{2}$ lb. of moisture it is 1670 B.t.u., and with 1 lb. of moisture it is 1510 B.t.u. One pound of moisture per 1000 cu. ft. corresponds to 7 grains per cubic foot, and is an amount which is very common in the summer months in almost all climates and may readily be exceeded by 30 or 40 per cent in the South and during July and August in the North. A half-pound is a fair average amount for spring and fall conditions in the greater portion of the iron-producing district.

The difference between these amounts, $\frac{1}{2}$ lb. per 1000 cu. ft., represents the difference between fair average conditions and reasonably good conditions. Now, quantitatively, this corresponds to just about 10 per cent more hearth heat per pound of fuel with the former than with the latter, and this ordinarily corresponds to about 10 per cent greater fuel consumption with the higher quantity of moisture. This is as compared, not with good conditions of three-tenths of a pound, but fair average conditions, on the one hand, while as before stated, the higher quantity taken corresponds only to very fair summer conditions; as between bad summer conditions, say $1\frac{1}{4}$ lb. of moisture, and the good conditions just noted, the difference is between 1750 and 1430 B.t.u. of hearth heat per pound of fuel, a difference of more than 20 per cent, which corresponds very closely to what has been found in practice in many cases.

Taking our rough figure of 10 per cent increase in fuel for $\frac{1}{2}$ lb. per 1000 cu. ft. increase in the moisture in the blast, let us translate this into terms of actual water. On a large furnace blowing, say, 40,000 cu. ft. of air per minute actual, this would correspond to 20 lb. or a little less than $2\frac{1}{2}$ gal. of water per minute, a very small quantity to cause such a vast difference in fuel consumption. This makes it very clear that a heavy leak due to the failure of a cooling member which may discharge into the furnace in a solid stream 20 or 30 gal. a minute will very quickly drown the furnace out, while very small leaks are amply sufficient to upset the delicate equilibrium upon which all successful furnace work depends, for on the basis of the above figures $\frac{1}{2}$ gal. a minute corresponds to a reduction of 1 per cent in the hearth heat, and a change of that amount is usually sufficient to alter the grade of the iron appreciably.

There is one feature about water leaks which may make them even worse than moisture in the blast. The latter is disseminated with absolute uniformity throughout the whole combustion space of the furnace and therefore produces no local irregularity, but when a leak takes place it tends to chill one side of the furnace while the rest goes on undisturbed. This brings about an irregularity which, added to the ruinous effect of the water itself, in whatever form it may be, makes water leakage the worst dreaded enemy of successful furnace operation. I suppose that every furnaceman has had the experience of having a good working furnace begin to work poorly and finally, after endless trouble, finding a small leak in some cooling member, the amount of water passing through which seemed as though it must be absolutely insignificant, and yet when the defective member was replaced by a perfect one the furnace at once returned to its normal condi-

tion and showed every sign that the source of trouble had been removed.

THE LEAKAGE OF WATER INTO THE FURNACE

In striving to maintain the cooling members intact we have to meet conditions perhaps the most severe of any in the operation of the blast furnace. It is absolutely impossible to maintain the furnace without cooling. The water-cooled members must necessarily be very thin or they will burn up in spite of the water cooling, and yet it is absolutely essential that the water must not reach the fire, from whose effects it is protecting the structure. Nothing suffices to maintain these conditions and the satisfactory operation of the furnace which depends upon them, except intelligent construction in the first place, backed up by vigilant and experienced operation.

The inner ends of all the cooling members in the hearth and bosh are in immediate contact with the currents of molten material and gas while the tuyeres are thrust right out into both and are exposed to the constant wear of the coke and to the drip of the iron and cinder running down the bosh walls. These members, therefore, necessarily fail from time to time, either by wear or by being cut by a particularly active jet of iron striking them from above and perhaps in many other ways. These failures lead to the direct flow of water in the hearth.

To determine whether a member has failed or not is one of the most difficult tasks in the operation of the blast furnace, for a tuyere may have a hole $\frac{1}{4}$ in. in diameter burnt in it, through which enough water will flow to chill the furnace in an hour or two, and yet superficial observation does not show the diversion of this water from the regular discharge of the tuyere, so it does not do to shut off these cooling members indiscriminately, because every one so treated is instantly destroyed when the blast is on, and very soon even when the blast is off the furnace. Those so destroyed must be replaced at great expense in money and far greater in loss of time, to say nothing of labor, before the furnace is in shape to go again.

There is no general method of determining whether a certain member is leaking or not if the leak be a small one. The presence of hydrogen in the gas in large quantities can always be detected by watching the combustion at the stoves and boilers, but while this proves the existence of a leak it gives no evidence as to its location, and sometimes the furnaceman will be hunting for days on the suspicion, or perhaps the certainty, that water is going into the furnace, without knowing where it is coming from. In some cases the plan has been adopted of pulling every cooling member in the furnace, not always at one shutdown, but stopping for a half-hour or an hour after every cast and pulling as many as possible, testing these under pressure outside the furnace for leaks and restoring them to place when perfect. This involves an enormous amount of labor, but, as before explained, the destructive action of water on the furnace is so great that a tiny leak is enough to affect the action of the furnace very seriously, and in some cases so destructively that whatever measures are necessary must be used to find it.

Perhaps one of the best methods of determining leaks is to throttle the water supply of the cooling member until the stream from its discharge flows absolutely smoothly, without spatter due to initial velocity, and yet without any break in the stream. By holding a light behind a stream of this kind gas bubbles can generally be seen descending in it if the member is leaking. A necessary feature of this method of test

is to throttle the pressure of the water in the cooling member down below the blast pressure inside the furnace, so that the gas comes in through the leak instead of the water going out.

Another method particularly effective in case of a leaking tuyere is to run a rod in through the peep hole to the nose of the tuyere, leave it for a few minutes and pull it out. In case of anything but a very small leak, the rod is frequently wet on the end.

Very often leaks can be detected by the wetness of the aperture through which the cooling member is inserted. The water is forced back in some rather mysterious way and makes its way out to the outside of the furnace. This is generally an excellent indication, but sometimes the water is so inconsiderate as to travel from the defective cooling member around a half dozen perfect ones and out through the butt of one of the latter, so that it is not safe simply to turn off the water supply from a member which shows wet around the base without investigating further.

There is always a certain amount of gas around the bosh of a furnace, not coming from any particular region that can be discovered, but nevertheless present all around it; the smell of this gas is altered to some extent by the presence of water going into the furnace, and this sometimes serves for a preliminary indication. The master mechanic of a small plant once said: "If you see old Wash (the colored keeper) get up and begin to walk around the furnace with his nose stuck up in the air, you may as well get ready to change a tuyere after cast."

It is impossible to do justice in print to this subject, so vital to the successful operation of the furnace. Nothing but several years of hard knocks around the plant suffices to impart a satisfactory education on the subject.

In order to prevent the difficulties which arise from the entrance of water into the furnace, various efforts have been made to supply a water circulation in which the pressure should be lower than that in the furnace itself, so that any failure would result in a little gas blowing out through the discharge, but not in the entrance of any water into the furnace. One of the schemes which has probably occurred to many is to pull the water through the cooling members by suction rather than driving it through under pressure, but the practical difficulties of maintaining pipe joints tight against vacuum, and the greater complexity necessary in such a procedure, have prevented it from being put into practical use in this country, so far as known to me.

But while there is difficulty in actually sucking the water through the pipes, much may be done to reduce the pressure required to make it flow. The volume desired should be obtained by large pipes under the lowest possible head rather than by smaller pipes under higher pressure. Above all, the discharge pipe should be direct and as free from bends as possible, because the end of this pipe being open, its frictional resistance is the measure of the pressure which must be maintained on the cooling member to produce the required flow. I do not think that enough attention has in all cases been paid to this important detail.

Another matter worthy of attention is the regulation of the water supply of the different members according to their requirements. It is extremely simple to turn them all on full head and run all the water possible through them, but this not improbably takes more heat out of the furnace than is required; it certainly requires an excessive amount of cooling water, and, above all, it maintains an entirely unnecessary pressure upon the cooling member with consequent liability to heavy leakage in case of failure.

In regard to the tuyeres and very often the coolers, the full flow policy is generally desirable, because the conditions to which they are exposed in the furnace are so severe that it is a wonder that any amount of cooling preserves them and we cannot afford to take chances of diminishing their water supply, but for many of the other members, a very much smaller supply of water suffices and they should be throttled down to the point where the water begins to be appreciably warmed in its passage through them, unless this leads to a water supply so small that it is likely to fail accidentally. No member should ever be throttled to this latter degree, because complete stoppage of such a choked water supply is almost sure to take place accidentally sooner or later. In this, as in all matters of furnace operation, there is no substitute for experience and good judgment.

In addition to the penetration of water into the furnace through leaky cooling members, much trouble has arisen in time gone by from water soaking in through the brick work at unprotected points and particularly where the jackets are used, from water entering between the jacket and the brick and thence soaking into the combustion space. It would seem that this action could not occur in view of the pressure of several pounds per square inch existing in the combustion space, but that it does occur most furnacemen know to their sorrow. The explanation probably is that the capillary attraction of the brick is stronger than the blast pressure and so draws the water inward in spite of the pressure outward.

Leaks of this kind can best be prevented by correct design in the first instance. Where steel jackets are used, the greatest care should be taken to see that the upper sheet laps over the lower sheet in every case. The spray trough at the base of the steel bosh jacket, if one is used, should be made amply wide to catch drip and spatter. Where a steel tuyere jacket is used, troughs should be provided above each cooler-opening so that any stray water running down is caught in these troughs and guided down over the side of the coolers away from the furnace. The steel tuyere jacket should have a conical base, riveted water tight to it, to run out over the top of the hearth jacket so as to shed any water which may fall upon it outside the hearth jacket and prevent its running down between the jacket and the brick work. Above all, if any sort of external spray be used on the hearth jacket, the latter should be made as absolutely tight as a high-pressure boiler, otherwise the water will find its way into the brick work and working through this, reach the hearth.

After proper construction of this kind has been provided, continuous watch must be maintained to see that water does not break through the defensive armor of the furnace in some unforeseen way and so make its way into the combustion zone.

Productos de la Ingersoll-Rand is the title of a catalog issued in Spanish by the Ingersoll-Rand Company, 11 Broadway, New York. It is attractively and substantially bound and contains 124 pages replete with illustrations, descriptive matter and tabulated data. The catalog covers completely the company's line of air and gas compressors, vacuum pumps, reciprocating and centrifugal water pumps, rock drilling, metal and coal mining, prospecting and quarrying machinery and pneumatic tools for machine and boiler shop and foundry work. In short this catalog is a complete reference book which should be of great service to Spanish-speaking users of pneumatic machinery.

Flotation Experiments on a Joplin Tailing

BY W. A. WHITAKER, GEORGE BELCHIC, ROY NEAL AND
H. L. VAN VELZER

The Joplin district of Missouri-Kansas is one of the largest regions in this country producing zinc and lead in which flotation has not been generally recognized and adopted, although encouraging signs in this direction have developed within the last few months with the installation of the process by at least one company and with its investigation by two others. During the year 1915, this district produced zinc and lead ores to the value of nearly \$27,000,000.¹

One of the authorities on the district, in commenting on some results obtained in this laboratory has stated² that "if the mill recovery of zinc in the Joplin district, averaging nearly 150,000 tons of metallic zinc for the last four years, could be raised from an average of 60 to 65 per cent to an average of 70 to 75 per cent (the recovery by flotation at Butte is probably about 95 per cent) it would add 25,000 tons of metallic zinc to the output of the district. Moreover, the increased saving would make deposits workable which were too lean to mine profitably before and thus further increase the output of the district." This figure when based on 20-cent spelter would have meant \$10,000,000 added revenue in 1915, and when based on the present prices would add a proportionate amount to the present year's income. It is thus seen that flotation is an economic factor which must be reckoned with by those who are concerned with the future of this district.

However, in studying the possible application of flotation here, there are several economic as well as technical factors which should be carefully considered. It has been recently pointed out³ that most of the mills of the district will average from 100 to 500 tons capacity per day of 10 hours; that the waste material is of two kinds, namely, that resulting from sheet-ground ore and that resulting from soft-ground ore, and under the assumption that 35-mesh material is fine enough for flotation, that "a 100-ton mill treating soft-ground ore will supply enough material to keep a 15-ton flotation unit running" and "a mill treating 200-tons of sheet-ground ore in 10 hours would produce about 10 tons of floatable material, provided most of this material can be collected." These quantities need not be taken, however, as limiting considerations, since the possibility exists of crushing economically some of the coarser material and thus adding to the quantity of possible floatable mineral. Also, future possibilities in the district might include greater capital invested, involving in turn the formation of larger companies, the construction of large mills, and a consequent larger output of tailings. This would mean, of course, still greater justification for flotation.

The object of the investigation herein outlined was to help along the possible application of flotation in the district by determining the behavior of various oils, or mediums, when used on a particular tailing, thereby determining those that give the richest concentrations and the highest extractions. In this work it has not been overlooked that the tailings of the district will vary in character and in zinc content, that the constituents of the various mine waters will vary, and, also, that a combination of oils may produce richer froths than a single oil, and, if not, that such combinations may be more economical to use. Experiments now being carried on will attempt to determine these latter points. However, as a beginning, it was thought ad-

visable to learn the behavior of the single oils on a single tailing before trying on a larger scale the many possible combinations on several tailings, since such data might allow the anticipation of such combinations, besides pointing out other interesting facts. The experiments tabulated in this paper were conducted during the period from Nov. 1, 1915, to March 15, 1916. They constitute a continuation of the flotation investigations begun in this laboratory in 1914 and hitherto published in outline.⁴

Experimental

In studying the behavior of these oils, the tests were run under neutral, acid and alkaline conditions, and with variations in temperature, and in the amount of oil and acid used. Under these conditions the percentage concentration and percentage extraction were determined. The oils used group themselves as follows:

Vegetable products	Drying
	Semi-drying
	Non-drying
Animal products	
Wood distillation products	
Coal distillation products	
Petroleum products	

No attempt was made to include a variety of rare, or unusual oils, which would not be applicable because of their expense. Some of those included, however, will come under the latter objection, but they were used because they represented one of the above groups, and because of certain physical or chemical properties which it seemed desirable to have represented. These properties are grouped for convenience of study in Table I.

One of the most important considerations in successful flotation is the composition of the water in which the process is carried out. The presence of certain colloids, of unusual acidity or unusual hardness may render impossible a process which has been successful on a similar material when a different water supply was used. The introduction of soaps, or of soap-forming constituents, such as saponifiable oils and alkali, in order to produce good frothing, may be rendered useless if the mill water contains hardening constituents which will react with the soluble soaps, precipitating them as insoluble soaps and thus obviating the lowering of surface tension with its consequent frothing effect. It seems reasonable to suppose that some of the tests recorded in this paper as carried out in an alkaline pulp, especially those with saponifiable oils, were partly vitiated because of the high Ca and HCO₃ content of the water used. These same tests if carried out in distilled water probably would yield much better results.

It may not be inappropriate to suggest here that if laboratory flotation testing should ever become a standardized procedure the tests will be carried out in distilled water and the necessary corrections, allowances, or modifications needed will be based on the composition of the mill water where it is intended to install the process. Engineers located in city laboratories, far removed from the mining districts, who make a practice of testing various ores for their amenability to flotation are liable to fall into serious error by ignoring this point. Future developments in flotation may reveal the justification for softening, neutralizing or otherwise treating the waters that are used in flotation cells. It may be more economical to treat a water in this way than to add the excess of oil which otherwise may be required, or to sacrifice recovery, by reason of the unusual composition of the water.

The water used in these tests was ordinary tap water

¹The Flotation of Joplin-Galena Slimes. This journal, Nov. 1, 1915.

²Zook, Engineering and Mining Journal, Jan. 8, 1916, p. 65.
³Stiebelthal, Mineral Resources of the U. S., 1914, Part I, p. 885.
⁴C. A. Wright Possibilities of Flotation for Lead and Zinc Ores in the Joplin District. Bureau of Mines (Multigraph Paper)

TABLE I—PROPERTIES OF OILS

Kind of Oil	Specific Gravity at 20° C.	Viscosity at 25° C. (Engler Viscosity-Inometer)	Surface Tension (Capillary method)	Saponification Value	Chief Constituents of the Oil
Castor Oil	0.958	159.00	43.50	176 - 183	Ricindein and its isomers. Small amounts of stearin.
Corn Oil	0.925	10.40	30.60	186 - 193	Palmitic, stearic, arachidic, linolic, and oleic glycerides ^{glycerides} . Small amounts of acetic and formic acids.
Cottonseed Oil	0.924	9.70	29.50	191 - 198	Olein, lindein, palmitin, and stearin.
Linseed Oil	0.933	6.25	34.50	186 - 192	Palmitin, stearin, and myristin. Oleic, linolic and linolenic acids. Small amounts of unsaponifiable matter.
Oleic Acid	0.902	7.90	23.70	190	About 94% free fatty acid—oleic, and 3% unsaponifiable matter.
Olive Oil	0.913	11.50	35.20	189 - 196	Olein, lindein, and palmitin.
Rape Seed Oil	0.915	11.70	29.80	171 - 179	Stearin, rapin, erucin and 0.41 - 1.43 % arachidic acid.
Sunflower Oil	0.922	8.65	29.50	186 - 194	Linolic and oleic glycerides.
Tung Oil (China Wood)	0.938	39.00	39.00	190 - 196	Olein and 75% elaeomargarin; 10% oleic and 2-3% saturated acids.
Fish Oil	0.935	7.00	35.00	197 - 203	Glycerides of liquid and solid acids; valerianic acid and some sperm oil.
Eucalyptus Globulus	0.850	1.37	24.20	—	6% aldehydes (butyric, isovaleric, and capronic); 21% pinene; 41% cineol; 25% alcohols, small amount of camphene.
Oil of Hemlock	0.870	1.15	30.00	—	Pinene, cadinene, bornyl acetate, and camphene.
Wood Distillate	0.931	1.11	30.10	—	Methyl alcohol, acetic acid, acetones, hydrocarbons, and tarry products.
Crude Wood Turpentine Oil #75	0.889	1.12	30.50	—	Terpene, pinene, resin, formic and acetic acids. Small amounts of camphene, dipentene, and traces of aldehydes.
Refined Wood Cresosote Oil #200	0.974	1.50	28.00	—	Cresol, phenol, creosol, and guaiacol.
Crude Wood Oil #500	1.008	5.21	22.60	—	Light rosin oils, light tar oils, creosol, phenol, benzol, pinene, and dipentene.
Pure Pine Oil #5	0.935	2.23	23.30	—	Laevo-menthone, limonene, and some of the higher boiling terpenes.
Pine Tar Cresosote Oil #7	1.020	1.37	28.00	—	Methyl ethers of catechol and its homologues; phenol, cresol, dimethyl pyrogallate, pitch, and other hydrocarbons.
Special Pine Tar Cresosote Oil #8	1.036	8.23	24.20	—	Phenol, cresol, dimethyl pyrogallate, and methyl ethers of catechol and its homologues.
Wood Cresosote Oil #17	0.973	1.39	37.60	—	Cresol, phenol, creosol, and pitch.
"Tarco" (Coal Tar Oil)	1.056	7.41	31.20	—	Coal tar derivatives containing phenol, cresol, naphthalene, toluene, anthracene, pyridine, and quinoline.
"Creco" (Coal Tar Oil)	0.960	2.12	29.60	—	Phenol, toluol and homologues.
Coal Tar Cresosote with Carbonic Acid #22	0.976	1.21	28.00	—	Cresol, phenol, creosol, naphthalene, phenantrene, and pyridine.
Crude Carbonic Acid	1.027	1.93	30.60	—	Phenol, cresol and homologues.
Crude Petroleum (Kerosene)	0.844	1.81	32.30	—	Mixture of hydrocarbons of various series together with a small percentage of nitrogenous basic matter, oxygenated bodies, and organic compounds with sulphur.
Paraffin Oil	0.876	4.50	30.10	—	Mixture of hydrocarbons of the paraffin series, obtained by purifying and decolorizing the fraction boiling above 300°C. obtained in the distillation of crude oil.
Sludge from acid in water	0.918	3.50	29.70	—	Mixture of compounds that are removed with the sulphuric acid in the acid treatment of the various distillation products from crude petroleum, chiefly aromatic hydrocarbons, tarry products, and sulphonic compounds.
Sludge soluble in water	1.020	1.10	28.20	—	A special preparation of sludge.

* Mixed - 5 parts of water to 1 part of sludge.

1. Petroleum Tar and Turpentine Co., Gulf Point, Florida.

2. American Naval Stores Co., 105 Broadway, New York.

3. American Coal Pitching Co., Denver, Colorado.

4. Sludge from which most of the sulphuric acid has been removed - Standard Oil Co., Indiana.

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from the city mains and is represented by the analysis⁵ given in Table 3.

TABLE III—ANALYSIS OF LAWRENCE WATER

	P.P.M.
SiO ₂	37.4
Fe ₂ O ₃ + Al ₂ O ₃	14
Ca.....	125.9
Mg.....	18.4
Na + K.....	37
Cl.....	46
SO ₄	71.6
HCO ₃	429

For comparison the analysis of Table 4 of waters from the Joplin district are included.⁶

TABLE IV—MISSOURI LEAD & ZINC CO., WELLS, JOPLIN ANALYSTS, CLEVELAND & MILLER

Depth.....	1387 ft.	910 ft.
Reacting values.....	P.P.M.	P.P.M.
Na.....	1.007	9836
Ca.....	1.844	2 196
Mg.....	1.405	1 781
SO ₄	2980	2994
Cl.....	3374	2814
CO ₂	3 620	4.380
H ₂ S.....	Present	
Total weight dissolved solids.....	336	396

Winslow Mine Water Webb City Analyst, V. H. Gottschalk		Chico Spring Galena Analysts, E. H. S. Bailey, L. McCullum	
REACTING VALUES			
	P.P.M.		P.P.M.
Na.....	2.065	Na.....	1.479
K.....	0.7855	Ca.....	2.285
Ca.....	4.037	Mg.....	5.590
SO ₄	1.229	Trace	
Cl.....	0.5358	SO ₄	1.353
CO ₂	3.039	Cl.....	0.987
		CO ₂	1.51
Total weight dissolved solids.....	350	Total weight dissolved solids.....	243

It seems reasonable to suppose that the possible presence in any of the Joplin waters of acids, salts of calcium and of other metals, should not interfere with successful flotation, since many of the results tabulated here were successful in the presence of a relatively high acid and calcium content.

The tailing used in these tests is much finer than the average material for the district. It was taken from a pond in Galena and is described by the screen and chemical analyses given in Table 5.

TABLE V—SCREEN ANALYSIS

	Mesh	Weight, Grams	Per Cent	Per Cent Cumulative	Per Cent Zinc
All pass.....	80	.....	.....	.....	.....
Retained on.....	100	5.0	1.02	1.02	1.24
Retained on.....	150	4.0	.81	1.83	1.91
Retained on.....	200	10.0	2.04	3.87	3.26
Through.....	200	472.0	96.13		3.65
Totals.....		491.0	100.00		

CHEMICAL ANALYSIS

	Per Cent
Zinc.....	3.61
Lead.....	.31
Iron.....	.53
Insoluble.....	94.72

The machine used was a small laboratory size of the mechanically agitated type. Lyster or Hoover design, and consisted of an agitating compartment and a floating compartment.

Method of testing: To the agitating compartment of the machine were added:

2000 grams of water

400 grams of tailing

varying amounts of oil (See Table I).

The mixture was agitated for 2 minutes with a

propeller speed of 1800 r.p.m. and for the following 5 minutes agitation was continued, with the door separating the two compartments, opened, so as to allow the froth to form and gather in the flotation compartment. The collected froth in the flotation compartment was removed by skimming and overflow, after a total of 7 minutes agitation, and was dried, weighed and assayed for zinc content. The machine was cleaned of gangue, and a fresh charge added.

Discussion

The following discussion is based upon the results tabulated in Table II. The term "neutral pulps" refers to pulps in which neither acid nor alkali has been used; by "low acid pulps" is meant pulps to which 4 lb. of concentrated sulphuric acid have been added per ton of dry tailing; by "high acid pulps" is meant pulps to which 8 lb. of concentrated sulphuric acid have been added per ton of dry tailing, and by "alkaline pulps" is meant pulps to which 8 lb. of sodium hydroxide have been added per ton of dry tailing.

Castor.—The highest concentrated was 47.5 per cent, produced by using 4 lb. of oil per ton of tailing in the low acid pulps. Increasing the amount of oil did not produce a richer froth in this acid condition, nor in the high acid pulps, nor in the neutral pulps. The same quantity of oil used in the alkaline pulp produced a very lean froth. Castor possesses the highest viscosity of any of the oils used. Extraction increased with increasing quantities of oil reaching a high point, 73.4 per cent, with 12 lb. in a neutral pulp.

Corn.—With this oil the richest froth, 47 per cent, was obtained under the same conditions as in the case of castor oil, 4 lb. of oil in the low acid pulp. Here, also, increasing the oil did not produce richer froths under any of the conditions tried. Extraction increased with increasing quantities of oil, reaching 55.43 per cent in a neutral pulp, and 77.50 per cent in an alkaline pulp.

Cottonseed.—The richest froths produced by this oil were obtained in a more acid pulp than in the preceding cases. Two (2) lb. of oil in the high acid pulp gave a 51.1 per cent froth. Increasing the oil did not increase concentration save in a very slight degree, where 8 lb. were used. Extraction increased with increasing oil reaching a maximum at 48 per cent.

Linseed.—In the case of linseed, also, the richest froths were produced in the high acid pulps reaching the highest concentration, 55.71 per cent with 6 lb. of oil. A lesser amount of oil, 4 lb., produced approximately as rich a froth. However, with this oil, extractions were higher in the low acid pulps. Linseed was used because it is a typical drying oil and because of its tendency to partially oxidize when subjected to extreme aeration, as would be the case in flotation, and become more viscous. Cotton-seed, rape seed and certain other oils behave similarly but to a lesser degree. It is interesting to note in this connection that the concentrate produced by linseed was the richest obtained in this series of more than 270 tests.

If it were possible to have a froth consisting only of water, air, oil and zinc sulphide, and with no gangue present, this froth when "broken" and dried should assay 67.1 per cent zinc, that is, the theoretical per cent of zinc is ZnS. The above concentrate which ran 55.71 per cent zinc is, therefore, an unusual case of mineral selectivity, and especially so, when we consider the zinc assay of the original tailing, namely 3.6 per cent. It represents a concentration of 1 to 15 pulps.

Oleic Acid.—Lean froths were obtained with this medium, the best being a 34.1 per cent concentrate with

⁵Haskings & Young, Water Supplies of Kansas, Eng. Bul. No. 5, Univ. of Kansas.
⁶Siebertthal, Origin of the Zinc and Lead Deposits of the Joplin Region, Bul. 606, U. S. G. S.

TABLE II—RESULTS

Kind of Oil	Condi- tion of Pulp	Temperature of Pulp 20°C.				Temperature of Pulp 20°C.				Temperature of Pulp 70°C.			
		Amount of oil used per ton of pulp	Assay of oil, percent	Assay of pulp, percent	Percent extraction	Amount of oil used per ton of pulp	Assay of oil, percent	Assay of pulp, percent	Percent extraction	Amount of oil used per ton of pulp	Assay of oil, percent	Assay of pulp, percent	Percent extraction
Castor Oil	neutral	6.5	0.5	22.75	23.00	2.5	0.2	24.51	25.50	6.0	0.3	36.94	33.10
		8.0	0.4	42.50	54.00	6.0	0.3	44.97	44.30	8.0	0.4	40.18	29.00
		12.0	0.6	43.09	73.40	8.0	0.4	37.80	60.70	12.0	0.6	42.87	60.00
Cotton Oil		4.0	0.2	36.87	21.70	4.0	0.2	47.00	35.64	4.0	0.2	36.82	23.00
		8.0	0.4	43.40	51.00	8.0	0.4	44.41	53.92	8.0	0.4	47.00	43.00
		12.0	0.6	40.00	55.44	12.0	0.6	37.50	58.00	12.0	0.6	45.42	42.00
Linseed Oil		2.0	0.1	28.80	14.30	2.0	0.1	48.70	27.30	2.0	0.1	51.70	16.30
		4.0	0.2	38.80	25.50	4.0	0.2	42.00	35.00	4.0	0.2	51.00	26.00
		6.0	0.3	39.50	43.10	6.0	0.3	42.10	60.00	6.0	0.3	52.70	46.00
Lime Oil		2.0	0.2	40.66	29.20	2.0	0.4	43.71	64.70	2.0	0.2	54.81	45.00
		4.0	0.3	38.46	36.70	4.0	0.4	37.29	68.50	4.0	0.3	55.71	48.00
		8.0	0.4	37.87	69.50	8.0	0.4	35.20	14.30	8.0	0.4	59.11	52.00
Olive Oil		2.0	0.1	6.54	4.30	2.0	0.1	3.50	14.30	2.0	0.6	16.00	42.10
		4.0	0.2	6.65	19.00	4.0	0.2	3.10	9.40	4.0	1.0	14.50	42.50
		8.0	0.4	6.61	49.00	—	—	—	—	—	—	—	—
Peanut Oil		6.0	0.4	16.45	7.00	6.0	0.4	36.03	27.50	6.0	0.4	15.63	20.60
		12.0	0.6	11.75	3.60	12.0	0.6	41.47	40.32	12.0	0.6	20.19	23.63
		20.0	1.0	14.00	28.40	20.0	1.0	39.25	46.30	20.0	1.0	41.40	46.10
Sesame Oil		4.0	0.2	15.36	10.15	4.0	0.4	23.21	28.00	4.0	0.2	25.00	22.00
		8.0	0.4	20.21	20.00	8.0	0.5	43.87	36.70	8.0	0.4	39.12	22.00
		12.0	0.6	25.80	19.70	12.0	0.6	35.62	55.00	12.0	0.6	45.70	60.30
Sunflower Oil		4.0	0.2	12.80	6.60	4.0	0.2	20.52	6.00	4.0	0.2	43.60	15.00
		8.0	0.4	14.70	5.50	8.0	0.4	11.00	14.00	8.0	0.4	46.30	30.00
		12.0	0.6	12.76	21.50	12.0	0.6	19.75	30.90	12.0	0.6	59.20	46.00
Tallow		4.0	0.2	12.76	—	4.0	0.2	12.76	—	4.0	0.2	12.76	—
		8.0	0.4	—	—	8.0	0.4	—	—	8.0	0.4	—	—
		12.0	0.6	—	—	12.0	0.6	—	—	12.0	0.6	—	—
Fish Oil		4.0	0.2	23.54	27.10	4.0	0.2	23.54	27.10	4.0	0.2	23.54	27.10
		8.0	0.4	23.54	27.10	8.0	0.4	23.54	27.10	8.0	0.4	23.54	27.10
		12.0	0.6	23.54	27.10	12.0	0.6	23.54	27.10	12.0	0.6	23.54	27.10
Eucalyptus Oil		2.0	0.05	21.38	39.00	2.0	0.05	21.37	13.30	2.0	0.05	27.00	75.00
		4.0	0.10	39.13	51.00	4.0	0.10	22.72	28.40	4.0	0.10	28.00	87.00
		6.0	0.20	21.00	25.00	6.0	0.20	25.15	31.30	6.0	0.20	29.30	98.00
Oil of Rose		2.0	0.05	45.23	36.00	2.0	0.05	46.30	32.10	2.0	0.05	46.30	32.10
		4.0	0.10	31.38	75.00	4.0	0.10	43.85	61.00	4.0	0.10	39.45	27.40
		6.0	0.20	25.68	75.00	6.0	0.20	24.22	61.00	6.0	0.20	38.40	16.00
Wood Distillate		2.0	0.1	25.00	47.20	2.0	0.10	23.00	30.00	2.0	0.10	19.30	15.10
		4.0	0.3	20.10	30.00	4.0	0.20	21.30	48.00	4.0	0.20	20.80	24.20
		12.0	0.6	16.20	41.10	6.0	0.30	37.40	43.30	8.0	0.40	27.25	35.00
Crude Wood Distillate		1.0	0.05	30.70	46.50	0.5	0.025	28.47	17.00	0.5	0.025	16.30	15.26
		2.0	0.10	21.88	77.50	1.0	0.050	39.60	30.20	1.0	0.050	13.60	16.20
		4.0	0.20	18.54	77.20	2.0	0.100	31.00	60.50	2.0	0.100	15.80	15.00
Crude Wood Distillate		0.5	0.025	16.51	10.15	0.5	0.025	24.47	19.30	0.5	0.025	37.30	17.50
		1.0	0.050	29.52	55.50	1.0	0.050	32.12	39.40	1.0	0.050	21.20	45.80
		2.0	0.100	9.60	96.00	2.0	0.100	25.00	81.40	2.0	0.100	15.00	85.20
Crude Wood Distillate		0.5	0.025	16.24	12.30	0.5	0.025	14.25	19.70	0.5	0.025	22.70	12.50
		1.0	0.050	32.51	12.30	1.0	0.050	30.00	29.10	1.0	0.050	21.00	17.30
		2.0	0.100	1.90	74.20	2.0	0.100	17.34	42.40	2.0	0.100	22.00	20.00
Crude Wood Distillate		0.5	0.025	45.72	44.42	0.5	0.025	36.23	55.40	0.5	0.025	55.20	42.60
		1.0	0.10	45.40	75.50	1.0	0.10	31.32	54.20	1.0	0.10	43.10	77.40
		2.0	0.20	45.00	30.00	2.0	0.20	36.10	55.50	2.0	0.20	42.40	74.00
Crude Wood Distillate		0.5	0.025	20.20	8.60	0.5	0.1	22.20	64.20	0.5	0.1	7.24	51.20
		1.0	0.10	21.70	54.00	1.0	0.2	16.00	70.00	1.0	0.2	0.68	59.00
		2.0	0.20	20.40	70.20	—	—	—	—	—	—	—	—
Crude Wood Distillate		0.5	0.025	16.47	12.30	0.5	0.025	39.63	16.40	0.5	0.025	23.14	17.60
		1.0	0.050	21.30	30.40	1.0	0.050	24.61	36.40	1.0	0.050	21.40	15.30
		2.0	0.100	5.51	61.60	2.0	0.100	10.19	55.00	2.0	0.100	24.20	16.20
Crude Wood Distillate		0.5	0.1	18.40	19.30	0.5	0.1	24.15	40.00	0.5	0.1	23.00	66.20
		1.0	0.2	15.80	59.00	1.0	0.2	14.00	61.00	1.0	0.2	13.00	64.20
		2.0	0.4	15.00	51.40	—	—	—	—	—	—	—	—
Crude Wood Distillate		0.5	0.025	24.00	23.46	0.5	0.025	25.30	23.10	0.5	0.025	27.40	11.40
		1.0	0.050	31.00	60.40	1.0	0.050	25.60	46.00	1.0	0.050	16.40	6.80
		2.0	0.100	19.00	66.50	2.0	0.100	35.30	67.00	2.0	0.100	28.30	9.60
Crude Wood Distillate		0.5	0.05	26.00	15.30	0.5	0.05	35.05	47.00	0.5	0.05	32.00	7.00
		1.0	0.10	26.00	52.00	1.0	0.10	33.90	64.10	1.0	0.10	17.00	7.60
		2.0	0.15	21.50	77.10	2.0	0.15	22.10	80.00	2.0	0.15	30.00	23.00
Crude Wood Distillate		0.5	0.1	33.60	21.10	0.5	0.1	23.00	19.00	0.5	0.1	25.20	12.30
		1.0	0.2	34.00	54.40	1.0	0.2	24.10	24.00	1.0	0.2	23.80	10.00
		2.0	0.6	30.00	87.30	2.0	0.4	47.00	46.00	2.0	0.4	34.30	24.00
Crude Wood Distillate		0.5	0.1	33.80	21.10	0.5	0.1	29.18	43.00	0.5	0.1	41.13	34.20
		1.0	0.2	34.00	42.10	1.0	0.2	27.00	47.00	1.0	0.2	36.30	20.60
		2.0	0.100	26.10	40.10	2.0	0.100	26.60	46.10	2.0	0.100	44.60	21.00
Crude Wood Distillate		0.5	0.1	31.00	21.10	0.5	0.2	3.00	12.10	0.5	0.2	—	—
		1.0	0.2	34.00	54.40	1.0	0.6	4.20	12.00	1.0	0.6	1.10	4.30
		2.0	0.4	34.00	54.40	2.0	1.0	6.10	40.00	2.0	1.0	0.50	1.30
Crude Wood Distillate		0.5	0.1	34.00	54.40	0.5	0.4	—	—	0.5	0.4	—	—
		1.0	0.2	34.00	54.40	1.0	0.6	—	—	1.0	0.6	—	—
		2.0	0.4	34.00	54.40	2.0	1.0	—	—	2.0	1.0	—	—
Crude Wood Distillate		0.5	0.1	34.00	54.40	0.5	0.1	—	—	0.5	0.1	—	—
		1.0	0.2	34.00	54.40	1.0	0.2	—	—	1.0	0.2	—	—
		2.0	0.4	34.00	54.40	2.0	0.4	—	—	2.0	0.4	—	—
Crude Wood Distillate		0.5	0.1	34.00	54.40	0.5	0.1	—	—	0.5	0.1	—	—
		1.0	0.2	34.00	54.40	1.0	0.2	—	—	1.0	0.2	—	—
		2.0	0.4	34.00	54.40	2.0	0.4	—	—	2.0	0.4	—	—
Crude Wood Distillate		0.5	0.1	34.00	54.40	0.5	0.1	—	—	0.5	0.1	—	—
		1.0	0.2	34.00	54.40	1.0	0.2	—	—	1.0	0.2	—	—
		2.0	0.4	34.00	54.40	2.0	0.4	—	—	2.0	0.4	—	—
Crude Wood Distillate		0.5	0.1	34.00	54.40	0.5	0.1	—	—	0.5	0.1	—	—
		1.0	0.2	34.00	54.40	1.0	0.2	—	—	1.0	0.2	—	—

OF TESTS

Temperature of Pulp 20°C.				Remarks.
Condi- tion of pulp	Amount of oil used per ton of ore pounds	Assay con- centrate percent	Percent extraction	
not tested	—	—	—	
4.0	0.2	19.80	23.30	In neutral and acid pulp the froth formed is a thin sheet and is not beneficial. Acid and high temperature forms a more permanent froth. Alkali added to the pulp forms a permanent froth.
20.0	1.0	28.30	77.50	In neutral and acid pulp at low temperature paste froths form, which are not beneficial, but these are of short duration. High temperature produces selective froths, which tend to form a frozen froth.
2.0	0.1	48.80	46.00	In neutral and acid pulp at low temperatures, brittle bubble froths form. High temperature produces selective action and alkali added forms pulp 4.
4.0	0.2	18.24	17.00	In neutral and acid pulp at low temperatures partial bubble froths form. High temperature tends to make a more permanent froth, which is not beneficial.
2.0	0.1	6.44	7.10	In neutral and acid pulp, viscous frozen froth forms. High temperature has no apparent effect upon the frothing properties of the oil. Alkali tends to increase the collecting power of the froth.
4.0	0.2	5.37	36.30	
8.0	0.4	16.60	41.00	In neutral pulp the froth takes the appearance of a scum or thin sheet. Acid is beneficial, while high temperature makes the froth brittle. Alkali tends to make a frozen froth.
20.0	1.0	16.28	46.40	In neutral and acid pulp at low temperature, brittle bubble froths form, which in large quantities of oil are used. High temperature increases the selective action of the froth.
4.0	0.2	26.30	38.20	In neutral and acid pulp a thin sheet or scum-like froth forms. High temperature tends to form a bubble froth, while alkali forms a viscous frozen froth.
20.0	1.0	21.50	33.00	When small quantities of oil are used there is scarcely any tendency to form a froth. High temperature is detrimental, but alkali tends to make a viscous froth.
4.0	0.2	31.00	28.00	In neutral and acid pulp at low temperature froths of the bubble type form, but in small amounts. High temperature destroys the froth, and alkali is beneficial in that it tends to form a fairly persistent froth.
2.0	0.1	22.10	71.00	In neutral and acid froths at low temperature thin and brittle froths form. High temperature creates a more permanent froth while alkali tends to form a viscous, frozen froth.
2.0	0.1	25.00	80.00	In neutral and acid pulp at low temperature good froths form. High temperature tends to rupture the froth, while alkali forms a viscous, frozen froth.
2.0	0.1	24.04	78.50	In neutral and acid pulp at low temperature good froths form. High temperature tends to rupture the froth. Alkali tends to form a viscous, frozen froth.
1.0	0.05	28.10	66.30	In neutral, acid, or alkaline pulp this oil will form viscous frozen froths showing poor selective action.
1.0	0.05	21.00	54.00	When used in large quantities this oil forms viscous froths which carry the gangue minerals as readily as the sulphides.
1.0	0.05	24.40	84.00	In acid, alkaline or neutral pulp the froth formed is viscous and frozen, showing poor selective action.
2.0	0.1	13.00	80.00	In neutral and acid pulp the froth forms almost instantly showing good selective action. High temperature tends to make for better selective action of the froth. Alkali increases the frothing action, but decreases the selective action.
2.0	0.1	12.00	60.00	In neutral acid and alkaline pulp, this oil produces viscous froths, which carry the gangue as readily as the sulphide minerals. High temperature has the tendency of further increasing the collective power of the froth.
1.0	0.05	21.21	84.00	In neutral, acid, and alkaline pulp at low temperature good froths form, poor in selective action. High temperature tends to rupture the froth.
2.0	0.1	23.18	68.00	In neutral, acid, and alkaline pulp, this oil produces viscous froths showing poor selective action. Temperature has but little effect upon the frothing properties of the oil.
1.0	0.05	47.00	50.00	In neutral and acid pulp at low temperature, large viscous froths form. High temperature and a large quantity of acid is detrimental. Alkali tends to produce a good selective froth.
1.0	0.05	37.40	42.00	This oil appears to behave in all respects like "Torco".
4.0	0.2	36.20	45.30	In neutral and acid pulp, this oil acts both as a frother and collector, forming frozen froths. High temperature is detrimental in that it tends to rupture the froth. Alkali is beneficial.
0.5	0.025	16.00	15.00	In neutral and acid pulp brittle bubble froths form. High temperature weakens the froth and alkali is in part detrimental.
4.0	0.2	36.40	45.50	With a large quantity of oil and pulp neutral there is a tendency for the production of good froths. Acid is detrimental in that it tends to form a viscous, frozen froth with good selective action.
NO	froth formed	—	—	The oil rises to the surface of the floating compartment without any tendency to form a bubble froth or even a scum froth.
not tested	—	—	—	This oil is a good frother and collector and forms a viscous frozen froth. Acid is beneficial.
not tested	—	—	—	This oil is a good collector but shows poor selective action. In the frothing properties this oil resembles "Torco", in the action of alkali, but with many of the oils.

3. American Coal Refining Co., Denver, Colorado.
 4. Sludge from
 een removed—Standard Oil Co., Indiana.

4 lb. of oleic in the low acid pulp. Extraction reached a maximum at 49 per cent in a neutral pulp.

Olive. — The best concentration here, 41.47 per cent, was obtained in the low acid pulp, using 12 lb. of the oil. The best extractions were obtained in the same pulps. Froths obtained in neutral pulps were lean.

Rape Seed. — A high acid pulp gave the richest froth with this oil, the same condition which produced the richest froths with linseed and cotton-seed oils. Four (4) lb. of oil in the warm high acid pulp gave a 45 per cent froth. Neutral pulps gave lean froths. Extractions were highest in the high acid pulps.

Sunflower. — Here, also, the high acid pulps gave the richest concentrates, 43 to 53 per cent, and the highest extractions. Other conditions produced noticeably poorer results. Extraction increased with increasing amounts of oil.

Tung. — This oil gave poor results and, in many cases, no froth was formed. A large quantity of oil, 20 lb., yielded a froth of 27.73 per cent and an extraction of 21 per cent in a low acid pulp. In the alkaline pulp, concentration was slightly less and extraction was slightly higher than in the low acid pulp.

Fish. — With this oil in the low acid pulp, a 36 per cent froth, the maximum, was obtained, but this was accompanied by a very low extraction, 5 per cent. In an alkaline pulp, concentration was slightly less, but the extraction was 28 per cent.

Eucalyptus. — Here the best concen-

trations took place in a neutral pulp with small amounts of oils. The richest froth obtained, 39.13 per cent, was produced by 2 lb. of oil. In the high acid pulps extractions were unusually high, reaching a maximum at 98 per cent with 4 lb. of oil.

Hemlock.—Good concentrations were effected in both neutral and low acid pulps by using only 1 lb. of oil. Increasing the oil did not improve these results though extractions increased as usual, reaching a maximum at 83 per cent.

Wood Distillate.—Concentration was highest here in the low acid pulp, reaching 37.4 per cent with 6 lb. of the medium. As before, extractions generally increased with increasing oil. However, an alkaline pulp with 2 lb. of oil gave a higher extraction, 78.50 per cent, than did the neutral and acid pulps which contained greater quantities of oil.

Crude Wood Turpentine, No. 75.—The highest concentration was a 39.60 per cent froth obtained with the use of 1 lb. of this material in a low acid pulp. The highest extraction, 80.60 per cent, was obtained in the same pulp when 2 lb. of material were used.

Refined Wood Creosote, No. 200.—The tests with this medium show relatively high extractions accompanied by low selectivity for the mineral. In a neutral pulp extraction ran to 96 per cent, but this was accompanied by a very lean froth, 9.6 per cent. The best froth, 32.12 per cent, was obtained in a low acid pulp with 1 lb. of the medium.

Crude Wood, No. 500.—The best results with this medium were obtained under the same conditions as in the preceding case, namely, the richest froth, 30 per cent, resulted from 1 lb. of the medium in a low acid pulp and the highest extraction, 74 per cent, from 2 lb. of the medium in a neutral pulp. In an alkaline pulp, 1 lb. caused an extraction of 54 per cent with a froth of 21 per cent.

Pine, No. 5.—Pine oil produced good froths in neutral and in high acid pulps, reaching the maximum concentration, 53.2 per cent, with 2 lb. of oil in the high acid pulp. Low acid pulps do not concentrate so well with this oil. Extraction was highest, 80 per cent, in the alkaline pulp.

Pine Tar Creosote, No. 7.—Lean froths, with moderately good extractions, characterized this medium. A neutral pulp with 1 lb. of the medium produced a richer froth, 26 per cent, than any of the other conditions tried.

Special Pine Tar Creosote, No. 8.—A low acid pulp produced the richest froth, 34.61 per cent, with 1 lb. of this medium. Extractions increased with increasing amounts of the creosote when in neutral and acid pulps, but in an alkaline pulp, with only 1 lb. of creosote, it was higher, 84 per cent, than under any other condition.

Wood Creosote, No. 17.—Low concentrations with some good extractions characterized this medium. The best concentrate, 23 per cent, and the best extraction, 88.2 per cent, were obtained in a high acid pulp with 2 lb. of oil.

Tarco.—This medium was one of two of those tried that gave a higher froth, 47 per cent, in an alkaline pulp than in either neutral or acid pulps. The next richest froth, 35.6 per cent, was produced with 1 lb. of Tarco in a low acid pulp. A high extraction, 88.5 per cent, resulted with 2 lb. of tarco in a neutral pulp.

Creco.—This material seemed to act in the same manner as tarco, but to a lesser degree. Here, again, the richest froth under the conditions tried, 37.4 per cent, was produced in an alkaline pulp. Also, the next richest froth, 33 per cent, was produced in the low acid pulp with 2 lb. of creco. Maximum extraction reached 80 per cent with 3 lb. in the low acid pulp.

Coal Tar Creosote with Carbolite, No. 22.—This medium produced the maximum concentration, 43 per cent, in a low acid pulp when 8 lb. was used. The same quantity of medium gave a 39 per cent froth in a neutral pulp. With an increasing quantity in a neutral pulp extraction reached 83.3 per cent. In an alkaline pulp, concentration was more effective per pound of medium used, 4 lb. yielding a froth of 36.2 per cent, which was a higher yield than that produced by an equal quantity under neutral or acid conditions.

Crude Carbolite Acid.—The maximum concentration, 41.03 per cent, was produced in the high acid pulp using only ½ lb. of the medium. Judging the comparative froths obtained in all tests by the weight of the oil or medium used, this froth obtained with the use of ½ lb. of crude carbolite per ton, was the most effective result of all those tabulated. Extraction reached a maximum at 47 per cent with 1 lb. in the low acid pulp.

Crude Petroleum.—Concentration was here highest in the alkaline pulp with a froth of 36.4 per cent 4 lb. Froths obtained in acid pulps were lean. In a neutral pulp 8 lb of this medium yielded a froth of 35.6 per cent. In low acid pulps, extractions were fair when large quantities of oil were used.

Paraffin Oil.—The peculiar behavior of this oil in its non-frothing property confirms a statement recently made that an oil must contain suitable colloidal matter in suspension in order to produce a froth. By reason of the treatment to which this oil has been subjected in order to render it colorless, odorless and tasteless, it is assumed that all colloidal matter has been removed from it.

Sludge (insoluble).—This material was tested under two conditions only, in neutral and low acid pulps. The froths obtained in the low acid pulps were slightly richer than those obtained in the neutral pulps. Extraction reached 66 per cent.

Sludge (soluble).—This soluble material was not so effective in concentration or extraction as the insoluble sludge, all results being uniformly low.

TABLE VI. HIGHEST CONCENTRATIONS IN NEUTRAL PULPS

Medium	Pounds per Ton of Ore	Per Cent Zinc in Concentrates
Pine, No. 5	2	45.40
Hemlock	1	43.23
Corn	8	43.10
Castor	12	43.00
Linseed	4	40.66
Eucalyptus	2	39.13
Coal tar creosote and carbolite No. 22	8	37.4
Cotton seed	4	38.8
Sludge (insol.)	3	35.7
Crude petroleum	8	35.6
Tarco	1	32
Crude turpentine No. 75	1	30.70
Creco	2	28
Rape seed	8	26.21

TABLE VII. HIGHEST EXTRACTIONS IN NEUTRAL PULPS

Medium	Pounds per Ton of Ore	Per Cent Extraction
Refined wood creosote No. 200	2	96
Tarco	2	88.5
Coal tar creosote and carbolite No. 22	12	83.3
Crude turpentine No. 75	2	77.5
Creco	3	77.4
Hemlock	4	76
Crude wood No. 500	2	74
Castor	12	73.4
Pine, No. 5	2	72.5
Pine tar creosote No. 7	4	70.2
Special pine tar creosote No. 8	2	67.6
Linseed	8	63.5
Sludge (insol.)	4	61
Wood creosote No. 17	4	59

TABLE VIII.—HIGHEST CONCENTRATIONS IN LOW ACID PULPS

Medium	Pounds per Ton of Ore	Per Cent Zinc in Concentrates
Castor	4	47.51
Corn	4	46.3
Hemlock	1	47.87
Rape seed	12	43.71
Linseed	8	43.7
Cotton seed	4	43.7
Coal tar creosote and carbolic No. 22	8	43.7
Olive	12	41.47
Crude turpentine No. 75	1	39.6
Sludge (insol.)	3	38.15
Pure pine No. 5	1	38.1
Wood distillate	6	37.4
Fish	4	36.
Tarco	1	35.6

TABLE IX.—HIGHEST EXTRACTIONS IN LOW ACID PULPS

Medium	Pounds per Ton of Ore	Per Cent Extraction
Hemlock	4	82
Refined wood creosote No. 200	2	81.4
Crude turpentine No. 75	2	80.6
Creco	3	80
Pine tar creosote No. 7	4	79
Linseed	12	68.5
Tarco	2	67
Sludge (insol.)	4	66.1
Wood creosote No. 17	4	61
Pure pine No. 5	4	55.5
Rape seed	20	55
Crude petroleum	12	48.0
Coal tar creosote and carbolic No. 22	8	48
Wood distillate	4	48

TABLE X.—HIGHEST CONCENTRATIONS IN HIGH ACID PULPS

Medium	Pounds per Ton of Ore	Per Cent Zinc in Concentrates
Linseed	6	55.71
Pure pine oil No. 5	1	55.2
Sunflower	10	53.2
Cotton seed	8	52.7
Corn	12	45.7
Rape seed	12	42.8
Castor	12	42.8
Olive	20	31.16
Crude carbolic	9.5	41.03
Hemlock	2	39.15
Refined wood creosote oil No. 200	0.5	37.99
Coal tar creosote and carbolic No. 22	8	34.
Creco	3	30
Eucalyptus	4	29.3

TABLE XI.—HIGHEST EXTRACTIONS IN HIGH ACID PULPS

Medium	Pounds per Ton of Ore	Per Cent Extraction
Eucalyptus	4	98
Wood creosote No. 17	2	88.5
Refined wood creosote No. 200	2	85.2
Pure pine oil No. 5	4	77.4
Rapeseed	12	60.3
Castor	12	60
Pine tar creosote No. 7	4	59
Linseed	8	52
Cotton seed	8	48
Sunflower	12	48
Olive	20	46.1
Corn	8	43
Oleic	20	42.5
Wood distillate	8	39

The results of Tables 6 to 13 are taken from the several tests arranged under Table I, in order to show a few of the richest concentrates and the highest extractions obtained in neutral, acid, and alkaline pulps. Twenty-eight (28) oils or mediums were tested in each of the above pulps, and in all conditions, save the alkaline, most of these mediums were tested by using three (3) different quantities.

Conclusions

1. The tailing used is easily amenable to successful

flotation under many simple and economical conditions.

2. In general, the above tests on a zinc sulphide tailing show that in neutral and acid pulps, vegetable oils and the lighter wood distillates show good selection for the mineral and yield rich concentrates, while creosotic and phenolic mediums, on the other hand, do not show such selection between mineral and gangue, but yield high extractions. Some exceptions occur, however, and in the alkaline pulps the above observation does not apply.

3. The richest concentrates and the highest extractions were produced in the high acid pulp.

4. The most effective results probably would be obtained by using a good "concentrating" medium mixed with a good "extracting" medium, i.e. a combination of the mediums mentioned under (2).

Note.—Since the foregoing laboratory tests were made some successful experiments have been carried out at Galena, Kansas, with a commercial-size unit. Some of the oils listed above were used, and also combinations.

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Electric Furnace Anniversary.—A banquet commemorating the first anniversary of the initial heat poured in the Gronwall-Dixon electric steel melting and refining furnace was given Saturday night, July 22, at the Detroit Athletic Club by the John A. Crowley Company of Detroit, who control the United States and Canadian selling rights of this furnace. Attending the banquet were the heads of the engineering, laboratory, metallurgical, operating, sales, and clerical departments. The pouring of the first heat in the Gronwall-Dixon electric furnace, located at Michigan and Hubbard Avenues, Detroit, was the beginning of the first electric steel industry in Detroit. During the past year more than 5000 tons of chrome-vanadium, nickel-chrome, nickel, and other high-grade steels, have been made and poured from this furnace. A new and modern plant is being completed in Detroit having 10-ton units with 30,000 tons yearly output.



THE NEW MASSACHUSETTS INSTITUTE OF TECHNOLOGY

A School of Chemical Engineering Practice

BY WILLIAM H. WALKER

In the address delivered by President Maclaurin at the dedication of the new buildings of the Massachusetts Institute of Technology, published in full in the July 1 issue of this journal, he stated, "This—the adequate supply of properly trained men—is the cardinal doctrine of industrial preparedness recognized by thinking men to-day as one of the greatest necessities of the times."

While there will always exist some difference of opinion as to what constitutes a properly prepared man, there are certain qualifications with which he must be provided. For example, he must be well grounded in science, trained in the applications of its principles to daily problems, have acquired engineering points of view and angles of approach, and have developed business perspective with relation to industrial work. In short, there must be produced the *potential* engineer. When a man has acquired a solid foundation in science, has become an accurate observer, an exact and logical thinker, and has developed a love for the application of this knowledge to the investigation and solution of the many problems which industrial practice presents, he has done marvelously well; but he still lacks much that goes to make the successful engineer.

While it is true that the resourcefulness in applying theory to practice, the training in the solution of industrial problems, the general business perspective, and self-reliance, which in time complete the man's education and make him a *creative* engineer is obtained in its entirety only by years of experience, there is much which engineering schools have accomplished to render more quickly available the scientific education of the embryonic engineer. Without well equipped mechanical and electrical laboratories it would be a long and difficult step to pass from the small apparatus and light load of a physics laboratory to the heavy responsibilities of a power plant. But in operating and testing the commercial-sized units with which mechanical engineering laboratories are readily equipped, a measure of self-confidence and an appreciation of responsibility are obtained not otherwise possible. In addition to all this, the student translates for himself the fundamental principles of physics as exemplified in the laboratory into the application of these same principles in units and processes of commercial size and value.

But such facilities have to a very limited extent been available for instruction in chemical engineering. The

important and oft-times controlling difficulties inherent in carrying on a chemical process on a manufacturing scale are not present when this same process is conducted in a chemical laboratory. To duplicate the apparatus which has been designed and built for factory operation is possible, and in many cases well worth while. But in order to study its performance the apparatus must be operated—a process for which it was designed must be carried out. This procedure is obviously expensive and at best limited in its scope. A student cannot acquire the self-reliance necessary to operate a high-pressure digester holding 25,000 gallons of acid by experimenting upon one of a few liters capacity. He cannot learn how to meet difficulties incident to handling a filter press, an electric furnace, a multiple effect evaporator, a rotary kiln, and so on, if he has access only to such apparatus as the laboratory can provide. That experience which means power to execute comes only from contact with commercial sized apparatus operating under the conditions imposed by practice.

Neither can the student obtain that training in the application of the principles of science to the problems of chemical industry on which successful industrial research so largely depends, without an opportunity to live with chemical processes which are being conducted on a large scale. It is true that the research chemist must be able to visualize the hitherto unaccomplished fact, but on the other hand, the undreamed accomplishments of the future, while using methods and equipment now unrealized, will also undoubtedly to a large extent employ the apparatus and the processes of to-day, although along new and varied lines. A familiarity with what does and does not succeed in present practice is the best foundation for that soundness of judgment so essential in every research worker, and most especially in those who are to direct and guide the activities of our industrial research laboratories.

In view of the impossibility of developing the type of engineer outlined without greater breadth of method and of contact than is possible in our educational institutions alone, it is generally recognized that the industries themselves have a duty to perform in this regard, and that without their co-operation educational accomplishment must remain imperfect. On the other hand, no satisfactory scheme involving industrial co-operation with educational institutions has hitherto been proposed, and the conception and inauguration of such a scheme cannot but represent an educational advance of the first order.

Within the last few years a comprehensive plan of great promise for the more adequate training of chemical engineers along these lines has been originated and developed by Mr. Arthur D. Little, a member of the Corporation of the Institute of Technology and chairman of the visiting committee for the department of chemistry. The plan has been enthusiastically adopted, and is based upon the idea of a close co-operation between the Institute and certain selected manufacturing organizations in representative industries. It involves radical changes in the Institute curriculum for chemical engineering, and the location of a part of the Institute's instructional activity in the manufacturer's plant.

As Mr. Little points out in his report to the Corporation of the Institute, "any chemical process on whatever scale conducted may be resolved into a co-ordinated series of what may be termed unit actions, as pulverizing, mixing, heating, roasting, absorbing, condensing, lixiviating, precipitating, crystallizing, filtering, dissolving, electrolyzing, and so on. The principles underlying each of these unit actions are the same, however different the materials operated upon may be. Thus in a gas absorbing system, the laws of counter current absorption which control the action of an ammonia scrubber do not differ from those involved in making sulfite digester acid. The number of these basic unit operations is not very large and relatively few of them are involved in any particular process. The complexity of chemical engineering results from the variety of conditions as to temperature, pressure, concentration, etc., under which the unit actions must be carried out in different processes, and from the limitations, as to materials and construction and design of apparatus, imposed by the physical and chemical character of the reacting substances. It is possible to so select a relatively few industries that there will be represented by them all of the important unit actions of chemical industry."

Experience has shown that when proper provision is made the performance of a piece of apparatus may be studied without materially interfering with its output. Thus the principles of multiple effect evaporation or of counter-current lixiviation can best be understood by making properly designed tests upon a working plant involving these unit actions. In other words, it is possible, under careful regulation, to use a manufacturing plant as a chemical engineering laboratory, and not cut down its production or influence adversely the quality of product. Some of the advantages of such a method of engineering practice over a laboratory equipped for instruction only are:

1. A first-hand knowledge of the machines with which the plant is equipped, operating under conditions imposed by practice, the processes involved being considered as unit actions, the factors which control their efficient performance, and a general knowledge of the cost of chemical apparatus in its relation to cost of installation and operation.

2. A study of the unit operations of the plant and the process which is being carried on, as examples of the application of the principles of science to industry, their interpretation in terms of physics, chemistry and mechanics.

3. A general knowledge of modern methods of factory management and control, obtaining thereby some familiarity with the problems presented by the human element in industry.

4. The education which comes from taking part in the work of the plant; in acquiring some degree of self-confidence in handling industrial processes and large-sized apparatus.

To carry into execution Mr. Little's idea, a *School of*

Chemical Engineering Practice has been organized, which will increase in scope as experience is acquired. For the present it consists of five stations selected to furnish opportunity in specific fields of broadest general importance in chemical engineering. Each station will include a small instructional laboratory, drafting room and conference room, and will be provided with a projection lantern, such special library, drawings, and models as may be needed. It will be in charge of a director, who will be a member of the Institute faculty.

Station A. Located with the Eastern Manufacturing Company, Bangor, Me. Here will be studied:

1. That most important application of the principles of electrochemistry to reactions taking place in solution, namely, the decomposition of common salt, with the formation of hydrogen, caustic soda and chlorine. The unit operations here available for study are electrolysis, multiple effect evaporation with separation of a crystalline precipitate, caustic soda purification and concentration; absorption of gas of low partial pressure; agitation of both heavy and light liquids, and sedimentation of sludge.

2. The manufacture of bleached spruce pulp by the sulfite process. This is a high pressure-temperature reaction under careful analytical control, which involves most interesting equilibria.

3. The manufacture of poplar pulp by the soda process. In this process a study of the losses of soda through the cycle of operations is a most instructive one. It involves precipitation, sedimentation, filter press separation, systematic lixiviation and washing, and a determination of the soda lost in furnace flue gases by the Cottrell electrostatic separation principle.

4. The boiling, bleaching, and beating of rags for paper stock, and the manufacture of bond and ledger paper. This is both beater and tub sized, and is partly drum and partly loft dried. The opportunities for chemical engineering study here are obvious.

Station B. Located at Everett, Mass., with the New England Gas & Coke Company. Without going into detail, the opportunities here offered are readily appreciated. The company operates large by-product coke ovens and water gas plants, with all the apparatus incident to the recovery of naphthalene, benzol, toluol, tar, ammonia, etc. Every opportunity is here presented to study those high temperature reactions of hydrogen with various hydrocarbons which have become so important in recent years.

Station C. Located at Niagara Falls with the Carborundum Company. High temperature electrochemistry is here represented in all its phases. Powerful electric furnaces of both the resistance and arc types are in operation, making a variety of products. The apparatus for pulverizing, with accurate separation, is here seen at its best, systems of sieving and screening, hydraulic classifying, and pneumatic separation being in constant operation.

Station D. Located at Stamford, Conn., with the American Synthetic Color Company. At this plant will be studied the chemical engineering of organic chemistry. Fractional distillation, sulfonation, alkali fusion, nitration, reduction, crystallization, with all the necessary apparatus, are but a few of the operations here available.

Station E. Located near Allentown, Pa., with the Atlas Portland Cement Company. Large scale operations involving crushing and grinding in many types of machines are here offered. The chemistry of combustion and furnace control is nowhere studied to better advantage than in the mammoth kilns of this plant.

To obtain the greatest good from such splendid opportunities it is clear that this school must be a part

of a consecutive and consistent course of study. Not only must an adequate scientific foundation be laid before undertaking this chemical engineering practice, but provision must be made for taking advantage of the directness of purpose and enthusiasm for further scientific study which the factory work will create. This is accomplished by providing a Master's course in chemical engineering of five years' duration, including the entire summer between the fourth and fifth years.

The first three years are identical with those of the four-year Bachelor's course in chemical engineering as now offered at the Institute. At the end of the third year the student will elect either to finish the regular course of four years, receiving therefor the Bachelor's degree, or to spend two years and the intervening summer in study and receive both the Bachelor's and Master's degrees. From those students who elect this Master's course, including the school of chemical engineering practice, the faculty will select those whose attainments and character as shown by their previous record of scholarship and by other information are such as to indicate that the course can be creditably pursued.

At the beginning of the fourth year the men so selected will be divided into five groups, and one group sent to each of the five stations for a period of six weeks. (Experience may prove that this is too short a time to accomplish the greatest good.) At the end of each six-week interval the groups will change stations, so that by Sept. 1 each group will have occupied each station. After from three to four weeks' vacation these men will all return to the Institute for the fifth year of advanced work, graduating the following June.

It must be kept in mind that the students going out into these various industries do not go as employees of the industry, but as students in the school of chemical engineering practice. It is intended that the work in the plant shall be wholly educational, and the men are to be under the control and direction, not of the plant organization but of the director of the station, a member of the educational staff of the Institute.

While it is intended to give the men as much industrial experience as possible, having them take shifts in the ordinary routine of the factory, such work will be directed throughout to secure the maximum educational result, and the interpretation of the experiences and results of work in the plant will be accomplished by conference and drawing room exercises, which will take up no small fraction of the time spent in each station. It is expected in this way to avoid the weakness and inefficiency of previous schemes of co-operation by making no attempt whatever to have the student an economic asset to the industry, but planning his whole activity for its educational return to the student himself.

To secure this high educational efficiency from the contact of the student with the industry, it will be noted that the student has completed substantially the equivalent of a four-years' course in chemical engineering before entering upon the school of practice. This will make possible the full appreciation of the significance of every fact and the interpretation of every experience in the light of fundamental principles.

The work of the fifth year is advanced in character, broad in scope, and almost wholly elective, the purpose being to take advantage of the student's enthusiasm and to allow him to specialize in the line in which he has found by experience that he has the greatest aptitude and interest.

But the plan is a co-operative one, and while it is confidently expected that in the work carried on by these students entirely for its educational value, there will result an accumulation of data, much of which will

be of service to the industry concerned, yet this prospective return is not figured as an asset to the plan. As a return for the use of the factory as a chemical engineering laboratory the Institute proposes to establish and direct for each company concerned a research organization devoted entirely to the solution of its individual problems. While a laboratory will be maintained at each station, the extensive research facilities of the Institute will be available for work of a special character, and the faculty of the Institute will function as a consulting staff.

The earning power of industrial research is now too firmly established to require any argument to demonstrate the possibilities for co-operative service which the plan possesses. It is earnestly hoped that in it may be found an effective method by which science may be more closely linked to industry for the lasting benefit of each.

Hygroscopic Properties of Sodium, Potassium and Ammonium Nitrates, Potassium Chlorate and Mercury Fulminate

BY GUY B. TAYLOR AND W. C. COPE

One of the most important properties of substances used in explosive manufacture is that of behavior toward moisture. Thorough drying of many of the ingredients of explosives is required before mixing and many explosives must be packed in moisture-proof containers to prevent subsequent moisture absorption from the air.

The following experiments were undertaken by the Bureau of Mines in connection with studies of detonators (blasting caps) as the failure of a detonator is often a serious matter, and many failures are attributed to wet composition in the detonator charge. Precise information was sought regarding the conditions under which the mercury fulminate-potassium chlorate mixtures generally used in detonators would take up moisture from the air, and the rate at which it was absorbed. The salts sodium, potassium, and ammonium nitrates, are much used in explosives and were included in the studies, the methods of which are given below.

The behavior of soluble salts, not forming crystalline hydrates, toward atmospheric moisture follows very simple laws. If the partial pressure of the water vapor in the air exceeds the vapor pressure of the saturated solution of the salt, then the salt will take up moisture; if the partial pressure of water vapor in the air is less than the vapor pressure of the saturated solution no moisture will be taken up by the salt, but it will lose water to the air. If the two pressures are equal, then equilibrium occurs, and there is no exchange of moisture between the salt and the atmosphere. It should be noted, however, that this state of equilibrium does not correspond with any definite water content of the pure salt. Since the vapor pressure of pure water is always greater than that of any aqueous solution, it is evident that any substance containing a soluble constituent can never be in equilibrium with an atmosphere saturated with water vapor.

Observations concerning the absorption of atmospheric moisture have been made by various investigators: fertilizer materials by Brownlee,¹ soils by Lipman and Sharp,² and black powder by Kullgren.³ Studies on rate of absorption of moisture by sodium and ammonium nitrates, and explosives containing these salts

¹Published by permission of the Director of the Bureau of Mines.

²J. Ag. Sci. 2, 380-1.

³J. Phys. Chem. 15, 709-22.

⁴Z. ges. Schtess-Sprengstoffw.—6, 364 and 385.

when stored over sulphuric acid solutions have been made by the French Explosives Commission¹, Busnikoff² and Schuyten³ have also studied the rate of moisture absorption by salts.

Rate of Moisture Absorption in a Saturated Atmosphere

In measuring the rate of moisture absorption, the material was exposed in an open porcelain crucible over water under carefully regulated conditions and the increase in weight noted after lapse of certain periods of time. Ordinary quart jars closing with glass tops and spring clamps were filled 2 cm. deep with distilled water; into each jar was placed a copper wire tripod for supporting one crucible. The jars were then closed and submerged completely under water in a large thermostat. When sufficient time had elapsed for jars and contents to come to the bath temperature, they were elevated so that the necks emerged, the tops removed, and the crucibles placed on the tripods. After closing, the jars were again submerged. In order to prevent possible condensation of moisture the crucibles were warmed slightly above the bath temperature before being placed in the jars.

The thermostat was a large tank of water, 30 by 26 by 20 in., electrically heated and stirred and controlled by a toluene thermo-regulator within less than 1/10 deg. Keeping the jars at a constant temperature prevented condensation of moisture on the walls and assured constant conditions of humidity.

When a crucible was removed from its jar, it was covered with an aluminum cover and weighed immediately since it lost weight fairly rapidly in laboratory air. Each result was obtained from a separate crucible, none being returned to the jars after weighing. The crucibles were about 2 cm. deep and had flat bottoms 3.7 cm. in diameter so that the material was spread out over a surface of about 10.75 sq. cm. The following results were obtained at 25 deg. from 2.0000 grams of

material. The salts used were highest grade C. P. preparations, the ammonium nitrate Bakers and the other three salts Kahlbaum's "brown label." The fulminate-chlorate mixtures were taken from commercial detonators (blasting caps).

If the increases in weight be plotted against time the points for the pure salts fall very closely on straight lines. The curve for a mixture of the two salts, sodium and potassium nitrates, with only 5 per cent NaNO_3 first follows the NaNO_3 line and then inclines toward the KNO_3 line. (See Fig. 1.) The points for the two potassium chlorate-mercury fulminate mixtures lie close to the KClO_3 line. These results are as may be ex-

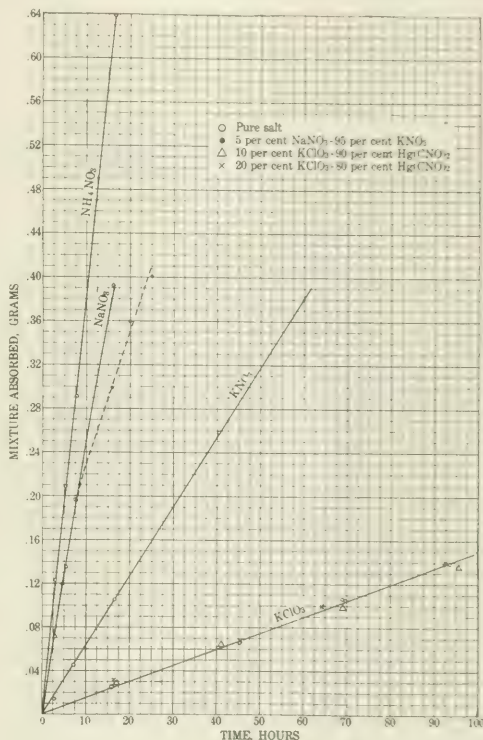


FIG. 1—HYGROSCOPIC CURVES

pected from theory. The vapor pressure of a saturated solution in equilibrium with two solid salts will be at least as low as that of the constituent whose saturated solution vapor pressure is lower, which will in general be the more soluble salt. The NaNO_3 — KNO_3 , containing only 5 per cent of the former begins to absorb moisture at the rate of pure sodium nitrate, which becomes slower as the amount of water taken up increases and the NaNO_3 goes into solution, eliminating one of the solid phases. Mercury fulminate is so slightly soluble that its influence in lowering the vapor pressure of the saturated solution of potassium chlorate is small, and mixtures of these two salts take up moisture at about the same rate as the pure chlorate.

It will be noted that the chlorate-fulminate mixtures absorbed approximately the same actual weight of moisture in a given time as the pure chlorate although the quantity of actual chlorate present was only one-tenth and two-tenths as much. It was found by experiment that in thin layers and with the same exposed surface, the quantity of moisture absorbed in a given time was

TABLE I—RATE OF MOISTURE ABSORPTION IN SATURATED ATMOSPHERE

	Hours	H ₂ O Absorbed, Grams
NH_4NO_3 (40-80 mesh)	3	.1234
	3 $\frac{1}{2}$	.2087
	7 $\frac{1}{2}$	.2913
	16 $\frac{1}{2}$	.6387
	3	.0713
NaNO_3 (40-80 mesh)...	3 $\frac{1}{2}$	.1355
	7 $\frac{1}{2}$	.1970
	16	.3924
	23 $\frac{1}{2}$	.0147
	18 $\frac{1}{2}$	.1136
KNO_3 (40-80 mesh)...	25 $\frac{1}{2}$	.1527
	42 $\frac{1}{2}$	.2687
	17	.2898
	7 $\frac{1}{2}$	.0453
	16 $\frac{1}{2}$	.1036
95 per cent KNO_3 , 5 per cent NaNO_3 ...	40 $\frac{1}{2}$	.2580
	29 $\frac{1}{2}$	.0752
	3	.1105
	16	.1960
	20	.2990
KClO_3 (40-80 mesh).....	25	.4010
	15 $\frac{1}{2}$	.0660
	69 $\frac{1}{2}$	.1056
	93 $\frac{1}{2}$	.1392
	122 $\frac{1}{2}$	.2340
KClO_3 (ground very fine)...	16	.0248
	66	.1062
	88 $\frac{1}{2}$	.1488
	142	.0262
	164	.0157
$\text{HgC}_2\text{N}_2\text{O}_7$ (F).....	17	.0290
	41	.0612
	69 $\frac{1}{2}$	.0980
	95 $\frac{1}{2}$	.1360
	110 $\frac{1}{2}$	.1674
90 per cent $\text{HgC}_2\text{N}_2\text{O}_7$, 10 per cent KClO_3 ...	16 $\frac{1}{2}$	.0316
	45 $\frac{1}{2}$	.0675
	64 $\frac{1}{2}$	.1000
	92 $\frac{1}{2}$	.1400
	110 $\frac{1}{2}$	.1400

¹Mem. poud. et salp. 16, 9-10 (1911-1912).

²J. Russ. Phys.-Chem. Soc. 32, 551-593 (1900).

³Bull. soc. chim. Belg. 26, 101.

independent of the weight as well as the fineness, within certain limits. For example 0.5 grams KClO_3 absorbed the same weight of moisture as 2.0 grams when exposed to a saturated atmosphere under identical conditions.

The results of Table II were obtained by exposing 2.0 grams of the salt over water in the same manner as above but at 35 deg. C.

TABLE II

	Hours	H ₂ O Absorbed, Grams
KNO_3	1 1/4	.0310
	4	.0612
	4 1/2	.0733
	10 1/2	.3137
KClO_3	20 1/4	.0847
	44 1/4	.1740
	68	.2887

Sodium nitrate in a partially saturated atmosphere, that is, over a saturated solution of potassium nitrate absorbed moisture as follows, 2.0 grams at 25 deg. C.:

7 hours	.1218 g.
16 hours	.2628
39 1/4 hours	.6955

Several experiments were made by exposing KNO_3 contained in vessels of varying heights and diameters filled to different depths with the salt. The weight of moisture absorbed in a given time in a saturated atmosphere is very materially affected by all these factors. In tall weighing bottles the rate of diffusion of water vapor evidently played an important part in determining the result. These results emphasized the importance of constant conditions in obtaining comparative results with the several materials. It should be pointed out, however, that the most important condition is maintaining constant conditions of humidity. For this reason exposing substances on watch glasses over water in ordinary desiccators at room conditions is a wholly unsatisfactory procedure for comparing the relative hygroscopicity or deliquescence.

Vapor Pressure of the Saturated Solutions

Marshall¹ has arranged a table of "relative deliquescence" of crystalline substances used in explosives assigning the value 1 to KNO_3 . The relative humidity, i.e., per cent air saturating in equilibrium with each salt for which there was no direct data, was calculated from Raoult's law. This figure subtracted from 100 and divided into the value for KNO_3 gave the "relative deliquescence." The values thus obtained at 20 deg. were for NH_4NO_3 , 7.6, NaNO_3 , 3.4, KNO_3 , 1.0, and KClO_3 , 0.23, while from the writers' experiments at 25 deg. C. the values are 6.3, 4.0, 1.0, and 0.23 respectively, which accord very well with Marshall.

Marshall's calculations are based on the assumption that the rate of moisture absorption is proportional to the difference between the partial pressure of water vapor in the air and the vapor pressure of the saturated solution. If this is true, from a knowledge of the vapor pressure of the saturated solution of one salt and the relative rates of moisture absorption in a saturated atmosphere, it ought to be possible to calculate the vapor pressure of saturated solutions of other salts.

The best available vapor pressure measurements of saturated solutions at ordinary temperatures are those of Speranskii.²

He used a tensimeter and measured the solution against distilled water. In the following table in the columns headed "calculated," the results were obtained from Speranskii's value for KNO_3 , 21.94 mm. at 25 deg. C. and our results on moisture absorption, together with Regnault's values for the vapor pressure of water, 23.55 mm. at 25 deg. and 41.83 mm. at 35 deg. C. These values for water are lower than those now generally accepted but were used in order to make use of Speranskii's formulas in calculating the observed vapor pressures of the saturated solutions.

	25 DEGREES		35 DEGREES	
	Calculated	Observed	Calculated	Observed
NH_4NO_3 . . .	13.4 mm.			
NaNO_3 . . .	17.11			
	17.25 (a)	17.32		
KNO_3 . . .	21.94	21.94	37.95	37.59
KClO_3 . . .	23.18	23.02	41.13	40.77

(a) Calculated from results over KNO_3 solution
(b) Used in all calculations.

The agreement between the observed and calculated values is well within all the experimental errors.

Absorption of Moisture by Detonators

The results obtained with the detonator compositions of mercury fulminate and potassium chlorate showed that the hygroscopic character of these compositions is almost entirely due to their chlorate ingredient. Tests were then made with commercial detonators of different grades, storing them over water in the jars in the thermostat. The results obtained showed that the rate of absorption is the same for all detonators having the same diameter, and is independent of the chlorate content and weight of the charge. The actual rate of absorption is shown to be very nearly proportional to the differences in the vapor pressures of pure water at the two temperatures and the vapor pressure of KClO_3 saturated solution. No. 5 detonators do not properly detonate with a moisture content as low as 0.01 gram per detonator. It should be noted, however, that fulminate-chlorate composition does not absorb atmospheric moisture at all unless the air is almost saturated, that is about 97 per cent between 0 deg. C. and 35 deg. C. a condition that obtains in practice only under exceptionally bad storage conditions.

MOISTURE ABSORPTION BY DETONATORS

Time, Days	MOISTURE ABSORBED AT 25 DEG. C.			Time, Days	MOISTURE ABSORBED AT 35 DEG. C.		
	L-178	M-54	M-1661		L-178	M-54	M-1661
2	.0020	.0019	.0016	3	.0080	.0080	.0082
4	.0041	.0038	.0038	8 1/2	.0217	.0215	.0222
6	.0061	.0061	.0065				
17		.0178	.0186				
25	.0202						

L-178—No. 5 detonator containing .50 gram charge of 90 per cent fulminate and 10 per cent chlorate.

M-54—No. 2 detonator containing 1.45 gram charge of 90 per cent fulminate and 10 per cent chlorate.

M-1661—No. 8 detonator containing 2.00 gram charge of 80 per cent fulminate and 20 per cent chlorate.

SUMMARY

The results described in this paper show that the hygroscopic properties of salts are a function of the humidity of the air and the vapor pressures of their saturated solutions. The relative rates of moisture absorption are proportional to the difference between the

¹Marshall, A.: "Explosives: Their Manufacture, Properties, T. 1 and History," McGraw-Hill, 1914, p. 314.
²Z. physik. Chem. 79, [1], 1913, p. 6.

partial pressure of moisture in the atmosphere and the vapor pressure of the saturated solution of the salt.

From a measure of moisture absorption, vapor pressures of saturated solutions may be calculated.

The tendency of detonators (blasting caps) to take up moisture from the air has been shown to be almost entirely due to the potassium chlorate which they contain.

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Revision of Our Chemical Statistics

BY BERNHARD C. HESSE

In a paper presented at the Philadelphia meeting of the American Institute of Chemical Engineers it has been pointed out that our chemical statistics need revision; a general plan or outline of plan therefore was then presented. At the Seattle meeting of the American Chemical Society in September, 1915, a committee was appointed to devise some practical and practicable way of obtaining such revision and of putting it into useful and serviceable effect. The organization of that committee was not completed until June, 1916. The reason for this delay is that service upon this committee entails a large amount of very difficult and most tedious labor, and men hesitate to assume such added responsibilities. Successful execution of this plan calls for co-operative thinking and planning on the part of all members of all chemical societies of this country and of all those engaged in chemical pursuits of any industrial or commercial aspect in this country.

Inspection of the lists of European countries for the past twenty years, so far as they relate to chemicals and allied materials, shows that these lists have been very greatly expanded and indeed much more so than our own.

In general, each European country seems to arrange its list with a view of telling its own people the most about other peoples and of telling other peoples as little about their respective affairs as is convenient, particularly in those items which are capable of high diversification. For example, the German list divides 120,000 short tons, or \$54,250,000 = 21.5 cents per pound of coal-tar dyes into four items only; photographic chemicals totaling 3080 short tons, or \$2,000,000 = 32.5 cents per pound, are lumped into one item, and 1320 short tons, or \$5,300,000 = \$2 per pound, synthetic pharmaceuticals also take up but one item. These six items total 124,400 short tons, or \$61,550,000, and average \$495 per ton, or 24.7 cents per pound, and cover fully 1800 different articles of manufacture, only few of them closely related; 123 short tons of various alkaloids and their salts of a total value of \$1,750,000, or \$14,220 per ton, or \$7.11 per pound make up one export item.

On the other hand, Switzerland in its lists is more diversified as to its imports from Germany than Germany is in its list of exports to Switzerland; in fact, Switzerland seems to enter and report trademarked or proprietary synthetics and the like as such; our own lists do this in isolated cases only.

German statistics for the calendar year are published within the first five weeks of the succeeding year; our own reports are two or three months later.

On its face, it seems plausible that if we are now to diversify our domestic chemical industry rapidly, and with the fewest false steps and commercial or industrial calamities, we should be advised in some authoritative manner as to the nature of our domestic market

as it is now and may develop to be in the future. If under these conditions we do not properly develop our markets and our domestic manufacture, we at least cannot reasonably raise the defense that we did not do better because we had no way of determining what our country's needs were, and therefore could not intelligently plan our independence from foreign supply sources.

I am encouraged in a belief in this utility and benefit by the rather large number of inquiries that have been made of me personally, orally and by letter, within the past twenty months for information as to the domestic consumption of this, that or the other imported article, and in only the fewest instances have I been able to dig up an answer that filled the bill.

It seems to me that there can be no debate on the general proposition that the more we know about our market requirements the more likely are we to build up a domestic industry. Add to this the fact that at comparatively little added expense our federal government, through one or more of its departments, can gather and promptly publish such added information, and it seems to me to be conclusive that the chemists of this country should get together, make up a list of such specific added items they need to be informed about, and indicate such further diversifications of items as to them promise the greatest help in the future.

We can rest assured that the number of different chemical materials and products that this country will use and continue to use will be not at all diminished in the future, but quite on the contrary will be greatly and very likely rapidly increased. The longer we put off such diversification of our lists the harder the task of future diversification will become; it will certainly not become any easier.

Such a request for added information has nothing in common with asking for a subsidy or a bonus or added tariff protection; it is simply a request to be better informed as to the requirements of the public so that we may more intelligently work towards our nation's industrial independence of foreign supply sources; in so helping us the public will be helping itself.

In presenting to the proper authorities a request for added information we must make as reasonably sure as possible that whatever is presented is not half baked, but is as mature as circumstances and conditions will permit; that it meets with and embodies the views of the great majority of those likely to be affected by this information, and that there is a reasonable stability to that list; such request should be in as definite final form as possible.

Clearly, the constructing of such a request is by no means whatever the duty of any one man or of any small group of men; it is a duty in which every person in the country engaged in the making, selling and distributing of articles of this class fully shares; in fact, it is everybody's business. The committee of the American Chemical Society can act merely as a clearing house for requests, and then put them into a form that will be likely to receive the sympathetic attention and enlist the active co-operation of the officials who must supervise the details of gathering and publishing such material.

As chairman of this special committee of the American Chemical Society I have prepared a consolidated list of articles used or produced in or by chemical industries as they appear in the most diversified commercial reports of Austria, France, Germany, Great Britain, Italy, Sweden and Switzerland; italicized entries are to be found in the most diversified U. S. lists. This consolidated list is as follows:

LIST I

I.—MALT, OIL, FRUITS, INDUSTRIES, PLANTS, FRUITS AND PLANT JUICES.
Malt, excl., burnt and ground.
Rapeseed.
Castor beans.
Legs and sunflower.
Lansed and meal.
Palm kernels.
Kopra.
Hops.
Madderroot, Quercitron and other dye plants.
Opium.
Kino.
Acic and other fruit and plant juices.

II.—FERTILIZABLE PRODUCTS FOR INDUSTRIAL OR MEDICINAL USES

Cinchonabark.
Rhubarb root.
Cucum.
Cudbear.
Caraway, Iceland moss and other crude lichens; Tamarisks, stick-cinnamon; berries, leaves, flowers, etc. for medicinal uses. Insect powder and flowers.
Taro for coffee.
Vegetable waxes in natural state.
Wood for wood pulp, etc.
Wood charcoal and powder, charcoal briquettes.
Wood, flour and excelsior.
Roots for distillation. Roots for medicinal use.

III.—DYEWOODS AND TANNING MATERIALS

Logwood.
Fustic, Brazil wood.
Oreic.
Ground or fermented dyewoods.
Quabracho and other woods, in blocks.
Quabracho and other woods, ground.
Algarobilla, Dividivi and other n. s. p. f.
Palon.
Nygalls.
Myrabolans.
Cassia (brown and yellow).
Gambier (crude or refined).
Oak bark.
Coniferous barks.
Mimosa, mangrove, maletto and other tan-banks.
Oak, pine and chestnut—extracts.
Myrrail—extract.
Quabracho—extract.
Smacch—extract.
All other tanning extracts.

IV.—RESINS, LAKES, VARNISHES AND PUTTIES

Turpentine resins.
Kauri and other copals.
Banour, akaroid and other resins, oilbanur and other soft resins, gum-resins.
Gum-lac.
Shell-lac.
Acacia, ocakon, cherry, cutera and bassora-gums.
Tragacanth.
Scammony.
Gum varnishes, Bird-lime ex linseed oil.
Spirit varnishes. Shellac-putty.
Lacquers (non-spirit), asphalt varnishes, coach varnishes.
Sealing waxes.
Putty and putties n. s. p. f.
Asbestos pastes, asbestos pigments, asbestos putty.
V. CEMENTS AND CEMENTS
Cautchouc, crude or refined
Gutta percha, crude or refined.
Balata, crude or refined
Rubber, scrap or waste.
Cautchouc substitutes.
Couphon and manna.

VI.—ANIMAL AND VEGETABLE FATS AND OILS

Hog lard.
Oleum-caryne.
Cream-fat, beef marrow, etc.
Cream-fat tallow.
Beef and mutton tallow.
Bone-fat, fat-waste, stearin-oils.
Fish, whale and seal oil.
Fats, etc. from fish, whale and seal.
Horse fat, deer tallow, etc.
Pape oil.
Linseed oil.
Neau-oil.
Peanut-oil.

SEEDS AND

Olive oil.
Lavet and sulfur oil.
Cotton seed oil.
Castor oil.
Riceh, bone, corn, poppy, sunflower and other fatty oils.
Fat-oils in tins, bottles, etc.
Cocoa butter.
Cotton seed stearin.
Palm oil (palm butter-fat, etc.).
Palmkernel oil and fat.
Cocoon oil fat and tallow.
Vegetable tallow.
Vegetable Ivory.
Oleic.
Margarine.
Edible vegetable tallow.

VII.—ANIMAL PRODUCTS

Egg-yolk.
Egg-albumen.
Bees and other insect waxes, honeycombs.
Spermaceti.
Fish glue, agar-agar.
Glue-wish.
Bones, horns, hoofs, etc., not for cutting purposes.
Horn-waste for fertilizer.
Bone and other animal blacks; bone-ash.

VIII.—STARCH, SUGAR

Potato starch, green or dry.
Rice starch.
Corn, wheat and other starches.
Starch, gums, dextrins, burnt starch, paste, adhesives and gluten-meal.
Cane sugar.
Beet sugar.
Beet sugar, flats, sticks and cubes.
Beet sugar, ground.
Beet sugar, lump.
Beet sugar, ground refined.
Beet sugar, loaf.
Beet sugar, brown.
Beet sugar, confectioners.
Cane sugar, raw, solid or liquid.
Beet sugar, raw, solid or liquid.
All other solid and liquid sugars.
Sirups and molasses.
Starch, fruit and other fermentable sugars, burnt sugar.
Caramel, solid and liquid.
Invert sugar.
Milk sugar.

IX.—ALCOHOL, VINELAR, YEAST AND MINERAL WATER.

Alcohol, in barrels.
Alcohol, in bottles.
Vinegar of all kinds.
Methylated spirits.
Wine yeast.
All other yeasts.
Mineral waters, artificial, etc., incl. bottles.

X.—MINERAL AND FOSSIL RAW MATERIALS

Alumite.
Clay, common, potters', fire and pipe.
Kaolin and china clay.
Burnt clay, chamotte, Fayenc, etc.
Yellow, ochre, bole, Sienna and Verona carths.
Other earth-colors, artificial oxide iron, crude.
Chalk, white, crude.
Graphite, crude, ground and washed.
Pumice, Tripoli, crude, ground, washed or in bricks or tile.
Emery, crude, ground or washed.
Mineral abrasives, polishes and cleansers, crude, ground or washed.
Enamel and glasses.
Kieselguhr, quartz-sand, fire-stones.
Lime, slaked, limestone or lime mortar.
Magnesia.
Manganese, native or burnt.
Witherite, native or burnt, strontianite.
Lime phosphates (Apatite, phosphorite, coprolite, etc.).
Gypsum; kypsum—superphosphate.
Puzzolan, etc.
Portland and Roman cements.
Ground lime; tripolith.
Asbestos, crude.
Venetian chalk, crude, ground or burnt.
Talc, crude, ground or burnt.
Mica, crude.
Tin oxides and Cobaltite.
Feldspar, ordinary.
Fluorapatite, crude; Kryolite, natural.
Bauxenite and Tinsel.

Monazite-sand.

Falters and other earths and bituminous shale.

XI.—ORES, IRON, SLAUGS

Antimony ore and matte.
Antimony regulus.
Arsenic ores.
Lead ore.
Chrome ore.
Iron ores.
Gold ores.
Copper ores, inclusive of pyrites cinders.
Copper regulus.
Manganese ores.
Nickel ores.
Platinum ores.
Pyrites (Pyrrhotite, marcasite, etc.).
Silver ores.
Tungsten ores.
Zinc ores.
Tin ores.
Uranium, molybdenum and other ores n. s. p. f.
Gas-purifying masses containing iron or manganese; slags, slag felts, slag wools; ferrovanadium, sedge; ashes, pyrites-cinder, etc.

XII.—FOSSIL FUELS

Anthracite, bituminous and canal coal.
Lignite.
Peat-coke and peat fuels.
Coke.
Coal briquettes.
Lignite—briquettes.
Coke-like residues and artificial fuels.
Carbons, formed and crude; vegetable carbon.

XIII.—MINERAL OILS AND OTHER FOSSIL RAW MATERIALS

Lubricating and vaseline oils.
Crude petroleum; pitch and natural liquid asphalt.
Heavy gaselines, turpentine substitutes.
Gas oils.
Refined petroleum.
Crude gasoline.
Benzine, gasoline, ligroin, petroleum ether and similar refined light-oils.
Lignite, peat and shale-oils and other not otherwise specified mineral oils, tars and pitches.
Paraffine, crude and refined.
Soft paraffin.
Solid asphalt and asphalt bricks.
Asphalt-mastic, pitch, resin and wood cement.
Ozocerite and mountain-pitches, crude.
Refined ozocerite, ceresin.
Pitch and black wax.
Pitch-like petroleum residues heavier than water.
Shale-pitch; lignite tar, peat-tar, wood tar, birch tar.
Oil and water-gas tar.

XIV.—COAL, TAR, OILS AND PRODUCTS

Coal tar.
Carbolineum.
Coal tar pitch.
Resol, laboul, cumol, etc.
Anthracene, carbolic, cresosol and other heavy coal-tar oils and asphalt-naphtha.
Solvent-naphtha.
Naphthalene.
Anthracene.
Phenol, crude or refined.
Lime carbolate.
Pyridine bases.
Cresol, crude carbolic 100 per cent.
Anilin, oil and salts.
Isosulphuric acid.
Benzol chloride.
Naphthol, naphtholene.
Naphthol compounds.
Anthrachinone, nitrobenzol, Toluclidia, Resorcin, Phthalic Acid and other coal tar products.

XV.—WAXES

Prepared bees and other insect waxes.
Prepared vegetable waxes.
Vegetable wax waste.

XVI.—SOAPS AND FAT PRODUCTS

Ordinary soft soap; oils and fluid fats; Turkey red oil; liquid Creolin and like cleansers, soap substitutes in barrels.
Hard soaps. Creolin and like hard cleansers; soap substitutes and evaporated lyes not elsewhere specified.
Cake-soaps; liquid soaps, soap powders, papers and other soap substitutes.
Stearin, palmitin.

Tapers, candles and night-lights.

Photograph plates and rolls of wax or ceresin.
Crude glycerin.
Refined glycerin.
Soap waste lyes.
Paraffin ointment, vaseline, vaseline ointment, lanolin and lanolin preparations.
Rosin-soaps.
Degras.
Acid-crease.
Other lubricants made from fats or oils.
Shoebuckling, solid.
Yellow shoe polish.
Polishes made of fats, oils, soaps, alumina soap, artificial polishes.
Stearin, palmitin, etc., formed.

XVII.—CHEMICAL AND PHARMACEUTICAL PRODUCTS

Abram Salts:
 12-15 per cent K_2O , more than 15-19 per cent K_2O .
Abram Salts N. S. P. F.
Acetates, all other n. s. p. f.
Acetone oil.
Acid:
Acetic.
Acetylsalicylic.
Arsenic.
Arsenious.
Benzoic and sodium benzoate.
Boric.
Chlorosulfonic.
Citric.
Formic.
Hydrochloric (nitrohydrochloric).
Hydrofluoric.
Lactic.
Nitric.
Oxalic.
Phosphoric.
Salicylic and sodium salicylate.
Sulfuric:
 Non-fuming.
 Fuming.
 For fertilizers.
 Spent.
 Tannic and gallic.
Tartaric.
Acid, Anhydrides.
Acetic.
Sulfuric.
Alkaloids and other metals not specified.
Alkaloids, all other, their salts and compounds.
Alum.
Soda, potash or ammonia.
Chrome, iron or copper.
Aluminum:
Acetate.
Chloride.
Hydrate, artificial.
Oxide, artificial.
Sulfate.
Sulfite.
Sulfocarbonate.
Ammonia water.
Ammonium:
Carbonate.
Chloride.
Fluoride.
Nitrate.
Sulfate.
Ammonium compounds, not dyes.
Antimony:
Fluoride.
Oxalate.
Regulus or metal.
All other compounds n. s. p. f.
Are Carbon.
Argols, crude or refined (soda or potash).
Artificial and natural mineral water salts.
Artificial balsams, extracts and waters, not perfumes.
Arsenic:
Metal.
Sulfide.
Compounds, all other n. s. p. f.
Barium:
Chloride.
Chloride.
Hydrate.
Oxide.
Nitrate.
Peroxide.
Sulphide.
Beetroot Potash.
Benzonates n. s. p. f.
Bismuth salts.
Borne.
Brom or
Bromides of potash, soda, and iron.
Bromides n. s. p. f.
Bromoform and Iodoform.
Bromine organic compounds.
Bromine n. s. p. f.
Caffeine.
Calcium:
Carbide.

Ammonia nitrate	Wool grease	Bichromate	Wool grease
Ammonia perchlorate	Turkey red	Borate	Borate
Apatite	Linseed	Carbonate	Carbonate
Argois	Poppy seed	Sul	lithyl
Crude tartar	Rape seed	Sulfate crystals	lithyl
Rochelle salts	Peanut	Tarum	Palm kernel
Calcium tartrate	Hamseed	Ground tale	Stearite
Balsams:	Almond, sweet	Stearite	Soya bean
Copaiba	Sesame	Vanilla	Olive oil
Fir	Bean	Vanilla	Chinese nut
Canada	Olive	Vanilla beans	Nut
Feru	Orange	Tonka beans	Kerosene
Tolu	Lemon	Arsenic	Naphtha
Barium chloride	Peppermint	Sulfide of arsenic	Paraffine
Dioxide	Almond, bitter	Cinchona bark	Whale
Carbonate, precipitated	Anise	Bauxite	oleo-stearin
Blacking, polishing powders and creams	Ambergris	Bauxite	ores of gold
Bleaching powder	Anise	Bismuth	Silver
Caffin	Bergamot	Copper sulfate	Nickel
Calomel	Camomile	Acetate	Platinum
Corrosive sublimate	Camomile	Sub-acetate	Paris Green
Chalk, precipitated	Cassia	Bone dust	London Purple
Chloral hydrate	Cinnamon	Meal	Phosphates, crude
Satol	Cedra	Ash	Phosphorus
Phenolphthalein	Citronella	Crude	Photographic films
Urea	Lemongrass	Borates of soda, crude	Plumbago
Terpin hydrate	Civet	Lime, crude	Potash:
Acetanilid	Fennel	Bromine	Crude or black salts
Acetphenetidine	Jasmine	Cadmium	Carbonate
Antipyrine	Juniper	Calcium acetate, brown or gray	Sulfate
Glycero-phosphoric acid	Lavender	Calcium chloride, crude	Hydrate
Acetilsalicylic acid	Aspic	Calcium carbide	Nitrate
Aspirin	Limes	Calcium nitrate	Quinine Sulfate and all cin-
Guaiac carbonate	Neroli	Cement, Roman, Portland and other hydraulic	chona alkaloids
Thymol	Urganum (red and white)	Cerium ore	Radium and its compounds
Chloroform	Thyme	Chromate of iron	Selenium and its salts
Carbon tetrachloride	Valerian	Chromium, hydroxide, crude	Salt
Benzo	Morphine sulfate	Anthracene	Santonin
Naphthol	All other opium alkaloids	Anthracene oil	Sheep dip
Resorcin	Cocaine	Naphthalene	Soda arsenate
Toluol	Ecgonine	Phenol	Cyanide
Xylol	Barytes	Cresol	Sulfate (salt cake)
Toluidin	Blanc fixe	Cobalt and ore	Bi-sulfate (niter cake)
Xylidin	Satin white	Cochineal	Ash
Cuminid	Blues:	Sulfate of iron	Silicate
Nitrobenzol	Prussian	Cryolite	Nitrate
Binitrotoluol	Berlin	Cudbear	Soda bicarbonate
Benzidin	Chinese	Dividivi	Strontium oxide
Tolidin	Ultramarine	Fulminates	Carbonate
Dianisidin	Black:	Gambier	Styechine and its salts
Naphthylamin	Bone	Gambier	Sulphur
Diphenylamin	Ivory	Greases and fats for soap making	Pyrites
Benzaldehyde	Vegetable	Guano	Talcum, stearite, French chalk
Benzylchloride	Gas	Basic slags	Tanning extracts:
Nitrobenzol	Lamp	Chrome:	Ambrachio
Nitrotoluol	Cyanamide	Yellow	Hemlock Bark
Naphthylamin sulfo acids	Green	Lime-nitrogen	Oak
Naphthol sulfo acids	Ochre	Gunpowder and all explosives	Chestnut
Amidosalicylic acid	Sienna	Gutta percha	Nuts
Binitrochlorobenzol	Umber	India rubber, crude, scrap and refuse	Nutgalls
Diamidostilbendi sulfo acid	Spanish brown	Indigo	Terra alba
Metanilic acid	Venetian red	Iodine	Tin ore and metal
Paranitronilin	Indian red	Iridium, osmium, palladium, rhodium and ruthenium	Tungsten ores
Dimethylaminilin	Colcothar	Iron ore	Turpentine, Venice and spirits
Colbalt, oxide of	Litharge	Kieserite	Uranium oxides and salts
Colloidon	Orange, mineral	Kainit	Valonia
Ethers:	Red lead	Casein	Waxes vegetable or mineral
Sulfuric	White lead	Lard	Witherite
Amyl nitrite	Lead acetate	Asphalt, bitumen	Woodpulp:
Amyl acetate	Lead nitrate	Litmus	Mechanical
Ethyl acetate	Varnishes	Madder	Chemical
Ethyl chloride	Vermilions	Magnesite	Bleached
All other ethers and esters	Whitening and Paris white	Manganese, oxide and ore of	Unbleached
Extracts of:	Zinc oxide	Myrobolans	Metalles
Nutgalls	Lithopone	Oils:	
Persian berries	Zinc sulfide (white)	Birch tar	
Sumac	Zinc chloride	Cajeput	
Logwood	Zinc sulfide	Cocoonut	
Chlorophyll	Enamel paints	Cod	
Saffron	Paints		
Safflower	Colors		
Formaldehyde	Stains		
Fusel oil	Pigments		
Amylic alcohol	Crayons		
Gelatine	Smalts		
Glue	Ceramic fluxes		
Glue-size	Glass fluxes		
Isinglass	Potash:		
Agar-agar	Bicarbonate		
Glycerine, crude	Chlorate		
Glycerine, refined	Chromate		
Gum:	Bichromate		
Amber	Nitrate		
Arabic	Permanganate		
Senegal	Red prussiate		
Camphor, crude	Yellow prussiate		
Camphor, refined or synthetic	Salts of bismuth		
Chicle, crude	Gold		
Dextrine	Platinum		
Burnt starch	Rhodium		
British gum	Silver		
Ink and ink powders	Tin		
Iodoform	Soda, perfumed, toilet		
Potassium iodide	Medicinal		
Licorice extracts	Castile		
Licorice root	All other		
Cocoa leaves	Soda:		
Lime citrate	Benzoate		
Magnesia calcined	Chlorate		
Magnesia carbonate of	Nitrate		
Magnesia sulfate (Epsom salts)	Bicarbonate		
Menthol	Cause		
Oil:	Phosphate		
Cod	Hyposulfite		
Seal	Sulfide		
Herring	Sulfite		
Whale	Chromate		

indexed, and to have them accompany the final recommendation when and if it is presented to the officials in Washington. The work of the members of the local sections of the chemical societies and of this special committee will be greatly expedited if each such letter were to be accompanied by seven carbon copies to serve as working copies for the various committee members, and such effective co-operation will be more than repaid in speed and certainty.

The final recommendation of this special committee must be backed up, so far as possible, by individual letters, otherwise those recommendations might very properly be looked upon as the personal opinions of only a few; that would not be fatal, but it would be disadvantageous.

This special committee itself cannot possibly bring this plan to the attention of all interested; it must depend upon the co-operation of the members of the national chemical societies to bring this matter to the attention of local boards of trade, chambers of commerce or similar co-operative business organizations, and to the attention of individual concerns and corporations. Each member has his work to do, and this special committee counts with entire confidence upon a full performance.

Persons and corporations not members of a chemical society need feel no hesitancy whatever in taking active part in this work; write your suggestions to the secretary of the section of the A. C. S. or A. E. S. nearest to you. There are no formalities and there is no need to stand on ceremony.

With 55 centers of information-gathering located in 32 states of the Union and the District of Columbia a substantial consensus of opinion should be obtainable.

In addition to the foregoing list helpful suggestions may be obtained by consulting the weekly import and export lists that appear in the *Oil, Paint and Drug Reporter* of New York, and the daily lists of manifests of incoming steamers as they appear in the *Journal of Commerce and Commercial Bulletin* of New York; also the weekly and annual summaries of British foreign and domestic chemical trade as they appear in *The Chemical Trade Journal* may offer useful suggestions.

List V gives the name and address of the secretary of each local section of the A. C. S. and of the A. E. S., arranged alphabetically by States.

LIST V

LOCAL SECTIONS, A. C. S.

- Alabama:**
W. H. Beers, Jr., 2114 First Avenue, Birmingham, Ala.
- California:**
B. S. Drake, 5830 Colby Street, Oakland, Cal.
Henry L. Payne, 223 West First Street, Los Angeles, Cal.
- Connecticut:**
F. J. Marsh, c/o R. Wallace & Sons Mfg. Co., Wallingford, Conn.
- Conn.:**
G. S. Jamieson, 121 Linden Street, New Haven, Conn.
- District of Columbia:**
E. C. McKelvey, Bureau of Standards, Washington, D. C.
- Georgia:**
J. S. Brogdon, 70½ Peachtree Street, Atlanta, Ga.
- Idaho:**
H. A. Holaday, University of Idaho, Moscow, Idaho.
- Illinois:**
D. K. French, 2005 McCormick Bldg., Chicago, Ill.
Geo. F. Neal, 208 Chemistry Bldg., University of Illinois, Urbana, Ill.
- Indiana:**
H. W. Rhodehamel, 643 East Thirty-second Street, Indianapolis, Ind.
- Iowa:**
W. G. Graessler, Iowa State College, Ames, Iowa.
Perry A. Bond, Cedar Falls, Iowa.
- Kansas:**
W. B. Smith, 24 Federal Building, Kansas City, Kansas.
- Kentucky:**
P. L. Blumenthal, Agricultural Experiment Station, Lexington, Ky.
A. M. Breckler, c/o Jones & Breckler, Louisville, Ky.
- Louisiana:**
F. W. Liepener, 310 Custom House, New Orleans, La.
- Maine:**
I. M. Burghart, University of Maine, Orono, Me.
- Massachusetts:**
F. M. Hoyles, c/o McCormick & Co., Baltimore, Md.
- Massachusetts:**
L. B. Spurr, Mass. Inst. Tech., Boston, Mass.

- Michigan:**
James H. Bogart, 825 Y. M. C. A. Bldg., Detroit, Mich.
H. H. Willard, 802 Monroe Street, Ann Arbor, Mich.
- Minnesota:**
Sterling N. Temple, 1758 West Blair Street, St. Paul, Minn.
- Missouri:**
George Lang, Jr., 3601 Salena Street, St. Louis, Mo.
Albert G. Loomis, 518 College Avenue, Columbia, Mo.
- Nebraska:**
H. M. Plum, Dept. Agr. Chem., Lincoln, Neb.
- New York:**
J. A. Bridgman, Morse Hall, Ithaca, N. Y.
C. F. Smith, 52 East Forty-first Street, New York City.
Ray H. White, 730 Buffalo Avenue, Niagara Falls, N. Y.
H. H. Tozier, 26 Jones Avenue, Rochester, N. Y.
A. J. Salathe, Union College, Schenectady, N. Y.
F. S. Soshner, Bowne Hall, Syracuse University, Syracuse, N. Y.
- North Carolina:**
F. E. Carruth, West Raleigh, N. C.
- Ohio:**
E. K. Files, Univ. of Cincinnati, Cincinnati, Ohio.
F. O. Germann, Adelbert College, Cleveland, Ohio.
W. J. McCaughey, O. S. U., Columbus, Ohio.
- Oregon:**
Norman C. Thorne, 841 Brooklyn Street, Portland, Ore.
- Pennsylvania:**
Geo. C. Beck, 325 Wyandotte Street, South Bethlehem, Pa.
J. H. Graham, 113 West Main Street, Germantown, Pa.
W. C. Cope, U. S. Bureau of Mines, Pittsburgh, Pa.
- Rhode Island:**
Robt. F. Chambers, Brown University, Providence, R. I.
- South Carolina:**
A. C. Summers, University of South Carolina, Columbia, S. C.
- South Dakota:**
H. L. Jones, Dakota Wesleyan, Mitchell, S. Dak.
- Tennessee:**
Paul C. Bowers, 9 Garland Avenue, Nashville, Tenn.
- Vermont:**
C. E. Burke, Burlington, Vt.
- Virginia:**
W. A. Burrows, 1000 East Carey Street, Richmond, Va.
- Washington:**
H. L. Trumbull, University of Washington, Seattle, Wash.
- Wisconsin:**
H. T. McAllister, 404 Alhambra Bldg., Milwaukee, Wis.
L. F. Augspurger, Chemistry Building, Madison, Wis.
- LOCAL SECTIONS, A. E. S.

- New York:**
A. T. Hinckley, 548 Fifth Street, Niagara Falls, N. Y.
J. M. Muir, 239 West Thirty-ninth Street, New York City.
- Pennsylvania:**
S. S. Sadtler, 210 South Thirteenth Street, Philadelphia, Pa.
H. C. Ray, University of Pittsburgh, Pittsburgh, Pa.
- Wisconsin:**
O. F. Watts, University of Wisconsin, Madison, Wis.

Should there be any changes in local secretaries from the list above given, the person addressed as above can be confidently counted on to forward such communication to his successor.

The present plan is for this special committee to begin its preliminary list Nov. 1, 1916, complete it Nov. 15, 1916, publish this provisional list in the *METALLURGICAL AND CHEMICAL ENGINEERING* Dec. 1, and *Journal of Industrial and Engineering Chemistry*, Dec. 6, 1916, begin its final draft Feb. 14, 1917, close the final recommendations Feb. 28, 1917, and present its recommendations to the proper authorities in Washington before March 15, 1917; this will leave three and one-half months for Washington to make its decision and arrange for the gathering of the added information, if any, decided upon with the beginning of the fiscal year 1917-1918.

Delay or failure in getting suggestions to the local sections will hamper the special committee. Points of view cannot be considered unless communicated. Everybody's co-operation is not only necessary, but most cordially invited. If our list is not the best in the world to-day we must strive to make it so.

25 Broad Street,
New York City.

Fire-Resisting Materials—The Bureau of Standards, Department of Commerce, in connection with a general study of fire-resisting materials, is considering among other phases of the subject the development of a fire-resisting material for use in constructing, in whole or in part, the deck structures of excursion and passenger steamers. So far as may be applicable, the material when developed would also be considered in relation with other marine uses. The Bureau of Standards would be glad to receive from manufacturers samples of such materials as they consider suitable for the purpose, in order that they may be given consideration.

An Investigation Dealing with the Occurrence of Alumina Inclusions in Steel

BY ALBERT SAUVEUR

NATURE OF INCLUSIONS IN STEEL

By the term "inclusions" (or "enclosures"), the steel metallurgist refers to small particles of non-metallic and generally oxidized impurities mechanically held by steel after it has completely solidified. These inclusions are as a rule lighter than the metal in which they are imprisoned, and if the latter could be kept liquid for a sufficient length of time after their formation most, if not all, of these foreign particles would rise to the top of the ingot or casting. Owing to the very small size of some of them, however, and to conditions of manufacture, a small amount of these inclusions must of necessity be retained in the solidified metal.

The inclusions commonly described comprise silicates, chiefly of manganese and of iron (frequently called "slag"), and manganese sulphide (often associated with iron sulphide). The use of titanium as a deoxidizer may introduce some titanium nitride inclusions, while the use of aluminium for the same purpose may result in the formation of alumina inclusions through the oxidation of some of the aluminium.

PURPOSE OF THE INVESTIGATION

The present investigation was undertaken for the purpose of ascertaining whether the occurrence of alumina inclusions in steel could be detected under the microscope and of studying the characteristics by which these inclusions can be distinguished from other inclusions.

PAST LITERATURE

Barring one or two unimportant exceptions, I am unable to find in the literature dealing with inclusions any reference to the occurrence of alumina antedating Mr. Comstock's article presently to be described. Previous to his writing, alumina had not generally been considered as a distinct or, at least, as a distinguishable inclusion.

Referring to the use of aluminium as a deoxidizer, however, and to the resulting formation of alumina, Rosenhain¹ writes:

"A more powerful deoxidizing agent than manganese is furnished by aluminium, but this differs from manganese in two vitally important respects. In the first place, the oxidation product of aluminium is a particularly refractory substance—alumina—which has a strong tendency to remain in the molten metal in suspension as fine particles."

In a paper entitled "The Solid Non-Metallic Impurities in Steel," the author, Mr. Henry D. Hibbard, writes:

"If other elements have been added, such as Al, W, Cr, Ti, or V, their oxides and silicates may be present.

"The too plentiful use of Al in steel may have been condemned, partly at least, because it forms oxides or silicates in the metal, which, being insoluble and infusible, exist in the solid steel as very harmful sonims. Of course, to form the oxide there must still be some oxide of iron or manganese in the steel. If the metal were free from O perhaps the weakening effect of Al when added in greater quantity than a few hundredths of 1 per cent would not occur. So a part of the Al added in the ladle would form sonims which might be fluxed and floated out, while that added in the molds, if the steel were free from O, would not be oxidized, but would all be left to exercise its full effect in preventing the formation of gas-bubbles and the resulting blow-holes in the steel."

MR. GEORGE F. COMSTOCK ON ALUMINA IN STEEL

In an article entitled "A Study of Alumina in Steel,"

published in METALLURGICAL AND CHEMICAL ENGINEERING for Dec. 1, 1915, Mr. George F. Comstock describes the occurrence and appearance of alumina inclusions in steel. Referring to alumina inclusions, Mr. Comstock writes:

"These inclusions are in the form of small rounded spots, arranged close together in one elongated streak. They are of a very dark bluish-gray color, when examined with the white light of an electric arc, appearing black unless highly magnified, and it is practically impossible to polish them without forming little pits around each inclusion. If the polishing is done very carefully, these pits may be kept very small; but with certain methods of polishing the pits are made so large that the original inclusions cannot be seen at all.

If the specimen is not rotated constantly during the final polishing, the pits take the form of short scratches, and each inclusion will have a little tail, like a comet. It will be noticed in Fig. 1 that although this shows a longitudinal view of a bar, the individual inclusions have not been elongated by the forging at all, but merely the group as a whole has been drawn out into a streak.

"The difference between inclusions of alumina and ordinary slag or silicates in steel may then be summarized as follows:

"(1) Silicate inclusions will generally take a fairly smooth polish in a section prepared for microscopic examination, while alumina is very hard to polish without pitting. (2) Silicate inclusions are always elongated in the direction of rolling or forging, while alumina particles are not (the groups of particles are, of course elongated but not the particles themselves). (3) Silicate inclusions are often found of quite large size (as well as very small), while particles of alumina are always small, and do not seem to coalesce into large bodies even when closely grouped together. These characteristics of alumina inclusions agree with what is known of the properties of alumina. Its great hardness and brittleness would account for the pitting effect; its infusibility would account for the small size of the particles and the tendency not to coalesce; and both of these properties together would account for the particles not being elongated by forging or rolling of the steel in which they were embedded.

"All samples in which more than the merest trace of alumina was found by analysis were seen to contain the typical inclusions as described above, and those in which alumina was not found by analysis, did not contain these inclusions. Furthermore, those in which more alumina was found by analysis contained more of these inclusions than those in which only a very little was found. These facts have been considered as a good confirmation of the theory that the typical small inclusions, as described above, found in so many commercial steels, are chiefly, if not wholly, alumina."

INVESTIGATION

As a preliminary step I took photomicrographs at a magnification of 300 diameters of five samples that Mr. Comstock used in his work, and a comparison of these photomicrographs with those taken by him showed that both sets were very similar and that they confirmed Mr. Comstock's description of the appearance of the inclusions.

In Fig. 1 is shown under a magnification of 300 diameters the appearance of the longitudinal section of a bar forged from a steel ingot to which 0.144 per cent aluminium had been added during the teeming from the ladle to the molds. The steel was made at the Watertown Arsenal, Watertown, Mass., in a Tropenas converter. Both ferro-manganese and ferro-silicon were used in recarburizing and deoxidizing. The inclusions shown in the photomicrograph present the characteristics described by Mr. Comstock as pertaining to alumina inclusions, namely, small dimensions of the individual particles, dark coloration, string formation in the direction of the forging, but non-elongation of the particles themselves.

Attempts were made as follows to produce molten iron under such conditions as to preclude the occurrence in the solidified metal of any inclusions but alumina:

¹An Introduction to the Study of Physical Metallurgy, Walter Rosenhain, page 153.

²Transactions of American Institute of Mining Engineers, Vol. XLII, pages 803-822.

1. Thermit iron produced with an excess of aluminium.

2. Ingot iron melted with aluminium.

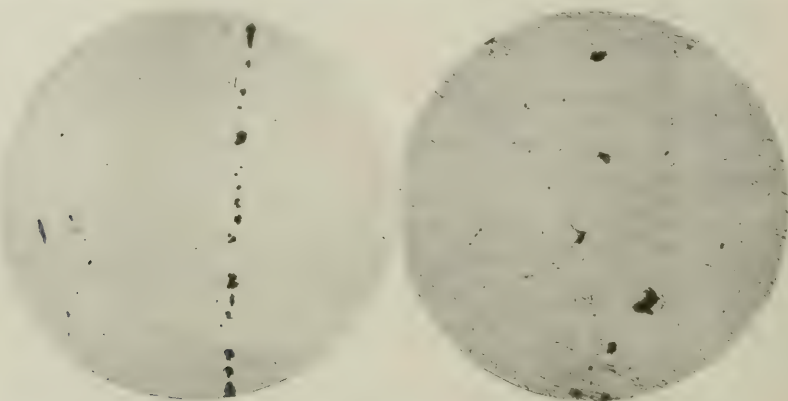
3. Ingot iron melted with alumina.

The results obtained will be briefly described.

Thermit Iron.—A small mass of thermit iron was produced in the usual way in a graphite crucible with

the absence of elongation in the direction of the forging.

Ingot Iron Melted with Aluminium.—A small amount of ingot iron was melted in an alundum crucible with the addition of aluminium. The expectation was that enough oxygen would be present to cause the oxidation of some aluminium and, therefore, the occurrence of alumina inclusions to the exclusion of all other inclu-



FIGS. 1 AND 2—MICROPHOTOGRAPHS

the addition of a small amount of finely powdered aluminium to the thermit mixture as commercially supplied. The small ingot was forged into a bar about $\frac{1}{4} \times \frac{1}{4}$ in. in cross-section.

It is believed that the thermit mixture practically consists of pure iron oxide and pure aluminium, and that any inclusions present must of necessity be alumina resulting from the oxidation of some aluminium.

A longitudinal section of the forged bar was prepared for microscopical examination and the polished but unetched surface photographed under a magnification of 300 diameters (Fig. 2). It will be seen to contain many small, dark and roughly rounded particles scattered

sions. The resulting mass was forged into a bar measuring about $\frac{1}{4} \times \frac{1}{4}$ in. in cross-section. A longitudinal section of the bar was polished and photographed under a magnification of 300 diameters. The presence of a number of small dark particles was clearly revealed (Fig. 3). They exhibit the characteristics previously described as pertaining to alumina inclusions, being small in size, dark in color, and non-elongated in the direction of the forging.

Ingot Iron Melted with Alumina.—Some ingot iron was melted in an alundum crucible with finely powdered alumina. It was assumed that while most of the alumina might float to the top of the molten bath, some of the



FIGS. 3 AND 4—MICROPHOTOGRAPHS

through the iron. It should also be noted that there is no indication whatever of these inclusions having been elongated by the forging. Although they do not occur in clusters or in strings, they present the chief features described by Mr. Comstock as characteristic of alumina inclusions, the most significant of which is

finest particles at least would be retained in the solidified metal as alumina inclusions. The small ingot was forged into a bar $\frac{1}{4} \times \frac{1}{4}$ in. in cross-section, and the appearance of a longitudinal section polished and magnified 300 diameters is shown in Fig. 4. Here again we note the occurrence of small dark inclusions scattered

through the mass and devoid of any tendency to elongate in the direction of the forging.

SUMMARY

From the results published by Mr. Comstock and confirmed by my examination of some of his samples, and from the results obtained in my own experiments as reported in the foregoing pages, it seems justifiable to conclude that alumina inclusions may be distinguished under the microscope from the other inclusions generally occurring in steel, being characterized by their small size, their dark coloration, and more especially by a complete absence of elongation in the direction of the rolling or forging.

Harvard University, Cambridge, Mass.

Synthesis of Tartaric Acid

The synthesis of tartaric acid is the subject of a patent of Dr. L. H. Baekeland and Arnold H. Peter (U. S. Patent 1,190,845, July 11, 1916). The process which is shown diagrammatically in Fig. 1 involves seven reactions marked respectively A, B, C, D, E, F, G. We quote the following description of the process from the patent specification.

(A) Carbon in any form, for instance, coke or charcoal, is introduced into a chamber or vessel provided with heating means. Into this vessel is conducted a colorless mixture of chlorin (which may be obtained later on in the process from reaction described in B or D or E or all of them) and water, preferably in the form of steam. When this mixture is conducted over the carbon heated to about 300 deg. C., there results hydrochloric acid and carbon monoxid or carbon dioxide or a mixture of the two carbon oxids. In ordinary practice, a mixture of the two oxides will result, it being usually not worth while to attempt to confine the production exclusively to either one. The hydrochloric acid thus obtained may be used in some of the reactions herein-after described either to promote said reactions or recover chlorid from their results, or both. The carbon-oxids may be used in making formates, as hereinafter described in B. Commercial requirements will determine whether both the acid and the carbon-oxids shall be used in succeeding reactions or one of them disposed of otherwise.

(B) From the carbon-oxids formate may be obtained in a variety of ways. For example, the mixture of carbon monoxid and carbon dioxide may be conducted over carbon heated to about red heat, reducing the carbon dioxide in the mixture to carbon monoxid, and the carbon monoxid may be conducted over an alkali (such, for example, as caustic soda, caustic potash, or others) heated to, say, 180 deg. to 220 deg. C., giving a formate. Or the carbon dioxide may be reduced to formate in a way which in itself affords an illustration of the process of the present invention.

Thus, water in a reaction chamber may be saturated with carbon dioxide (or the mixture of carbon-oxids containing it) and an amalgam, preferably produced by the electrolysis of a chlorid, may be caused to travel into such chamber, where it liberates hydrogen, reducing carbon dioxide to formate.

It will be observed that when this method is followed the reactions embrace the electrolysis of a chlorid, giving chlorin and a reducing agent, the utilization of the chlorin to assist in oxidizing a substance and the reduction of the oxidized substance by the reducing agent.

The hydrochloric acid resulting from the use of the chlorin with water (in the form of steam) to oxidize the carbon may be used to attack the amalgam, throw off the hydrogen from it for the reduction of the carbon dioxide and unite with the amalgam to form chlorid.

It may under some circumstances be desirable to use this cycle of chlorid, chlorin and amalgam, hydrochloric acid from chlorin, decomposing the amalgam to form chlorid and give off hydrogen, to reduce carbon dioxide obtained elsewhere.

For example, it may be, under certain circumstances, desirable to make the chlorin react upon the carbon in the presence of water or steam so as to produce hydrochloric acid and carbon monoxid almost exclusively (which may be made in this manner of exceptional purity) and dispose of the carbon monoxid, ob-

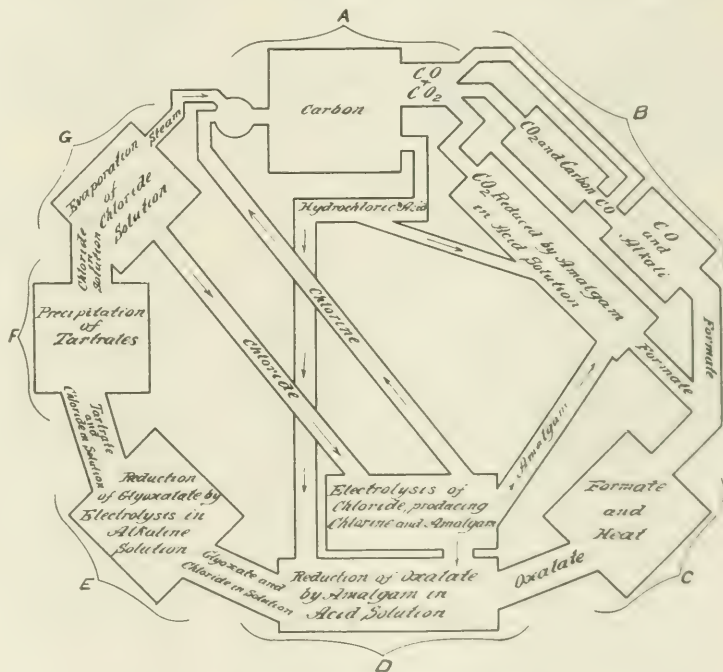


FIG. 1—SYNTHESIS OF TARTARIC ACID

taining the carbon dioxide to be reduced from some source not connected with the process.

The foregoing description of the reactions which have been designated B represents various ways of treating the substance oxidized with the assistance of the chlorin obtained from the chlorid or an equivalent substance so as to obtain formate. Any convenient way may be used. The further treatment of the oxidized product may be as follows:

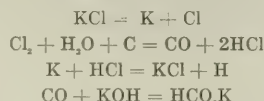
(C) The formate may be transferred into oxalate in any convenient way, as by heating the formate to, say, 360 deg. to 440 deg. C., under pressure.

(D) The oxalate may be reduced to glyoxylate by means of an amalgam, preferably in an acid solution. This amalgam may be made by the electrolysis of a chlorid, preferably potassium chlorid, generating chlorin at the anode, which may be mixed with steam and conducted over carbon, as hereinbefore described in A.

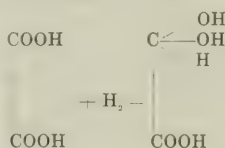
The amalgam thus produced may be caused to travel into a reaction chamber containing the oxalate and an excess of hydrochloric acid which has been obtained by conducting the mixture of chlorin and steam over carbon, as hereinbefore described in A.

The amalgam, being attacked by the acid in this reaction chamber, gives off hydrogen, reducing the oxalate to glyoxylate, and, after giving off this hydrogen, combines with the hydrochloric acid to form chlorid, which remains in solution and may either be recovered at this point and again electrolyzed or allowed to pass with the glyoxylate into and through the transformation of the glyoxylate into tartrate, as hereinafter set forth.

It will be observed that the reactions described form a complete cycle, which may be summed up as follows:



Oxalate of sodium in presence of an acid gives oxalic acid. The latter in presence of potassium amalgam and a strong acid gives glyoxylic acid:



(E) The glyoxylate may be introduced in solution rendered alkaline into the cathode chamber of an electrolytic cell, the electrolyte in the anode chamber being preferably an alkali chlorid, although other soluble chlorids, even chlorid of hydrogen, may be used. When the current is caused to pass through the solution from the anode to the cathode the glyoxylate is reduced to tartrates (racemic and meso-tartrates), which are precipitated, used and worked up, as may be desired.

If, as above suggested, the chlorid resulting from the reaction D has been allowed to remain in solution with the glyoxylate, it may be recovered after the tartrates have been precipitated, as, for example, by evaporation.

The chlorin developed on the anode in this reaction may be used in accomplishing the oxidation of the carbon, the carbon-oxyds being used to produce formates, which may be converted into oxalates, which may be converted into glyoxylates, which may be converted into tartrates, as above indicated.

The alkali formed in the cathode compartment may be neutralized by the hydrochloric acid formed from the chlorin generated in the anode compartment.

The apparatus availed of in the process and in the various reactions will differ according to the particular circumstances of manufacture. In commercial practice, it will often be desirable, for example, to store temporarily the products of the various reactions, as, for instance, the formate or oxalate or acid or chlorid, before using them, or to connect the various sources of

chlorin so that the making of the hydrochloric acid or the oxidation or both may be conveniently accomplished.

The process contemplates that variations will be made in it according to commercial requirements. Thus, for example, in certain manufactures some of the reactions hereinbefore described may be omitted and the substances developed by such reactions obtained and introduced otherwise. For instance, a chlorid may be electrolyzed to develop amalgam and chlorin, the chlorin being used with steam and carbon to give hydrochloric acid and the acid used to liberate hydrogen from the amalgam and unite with the rest of it into chlorid, but instead of using the carbon-oxyds (which may be obtained in connection with the making of the acid) through reactions producing therefrom oxalates or oxalic acid, the carbon-oxyds may be disposed of otherwise and oxalic acid elsewhere obtained and introduced.

The invention has been described as embodied in a synthetic process for the manufacture of tartaric acids and their compounds from carbon, and it is pointed out that it is applicable also in the manufacture of certain compounds produced therein, as formates and glyoxylates. It is to be understood that it is applicable also in other synthetic processes.

It is particularly to be observed that in the specific embodiment of the invention applied to the manufacture of tartaric acids, the manufacture is conducted and the product obtained with practical freedom from by-products. The carbon of the coke or charcoal is caused to unite with the oxygen and hydrogen of the decomposed water, the cycle of reactions of the present invention supplying the principal ancillary substances necessary to accomplish this in such manner that practically no by-products are left.

The Hord Color Products Co., Sandusky, Ohio, are building a large dye factory. Dr. D. Julian Block of Chicago has been active in developing processes.

Bituminous Coal Output—The estimates made by the Geological Survey for the first six months of 1916 are interesting as they reflect the great industrial activity which is going on in this country at the present time. According to the estimates, the output was 261,000,000, tons or the largest output ever recorded for a half year period. This is an increase of 35 per cent over the first six months of 1915 and of 5 per cent over the last six months of 1915. The exports to Canada have increased considerably.

The Nordberg Mfg. Co., Milwaukee, Wis., has issued Bulletin No. 28, describing poppet valve engines of three types, viz., full poppet, poppet-uniflow and poppet-Corliss. For ordinary non-condensing service, the high-speed, full-poppet valve engine shows the highest efficiency. For condensing service two types of engines are offered—Nordberg poppet-uniflow and Nordberg poppet-Corliss, the former being an engine with uniflow cylinder design, that is, exhaust ports in the cylinder barrel and poppet steam valves, and the latter a compound engine with a full poppet high-pressure cylinder and a Corliss valve low-pressure cylinder. The poppet-uniflow engine is particularly adapted to widely fluctuating loads on account of its flat steam consumption characteristic. Recently two of the largest uniflow engines so far constructed in this country have been shipped to the Youngstown Sheet & Tube Co., for steel mill drive. The poppet-Corliss engine is adapted to constant load or constant m.e.p. work, under which conditions it shows very high steam economy. A compound engine of this type, fitted to an ammonia compressor, showed by test a steam consumption of less than 10 lb. per indicated horsepower-hour.

The Flotation of Oxidized Ores*

BY O. C. RALSTON AND GLEN L. ALLEN

Concentration of natural sulphide ores by the flotation process has met with such success that attempts have recently been made to apply the process to the flotation of ores other than natural sulphides.

As inquiries on this subject are frequently received by the Bureau of Mines, it has been thought best to publish a summary of the results so far obtained from the experimental work on oxidized ores at the Salt Lake City station of the bureau, in co-operation with the department of metallurgical research of the University of Utah. The work has been directed by O. C. Ralston, assistant metallurgist of the bureau, and was carried on for the most part by G. L. Allen. N. C. Christensen and R. W. Johnson also assisted with the work.

As above stated, this paper is only a summary, or a preliminary report of the experiments on the flotation of oxidized ores. More complete details as regards the flotation of carbonate ores of lead will be given by the writers in a paper on that subject, and in the near future the bureau expects to publish a still more complete discussion on the flotation of oxidized ores of lead, copper and zinc.

Most of the experimental work in the laboratory at the Utah station has been with the oxidized ores of lead. Only minor attention has been given to the oxidized ores of zinc and of copper for the following reasons: Little success has been had with the zinc ores; many others are engaged in testing copper ores, so that there was no pressing necessity of experimentation with copper ores by the bureau, although an attempt is being made to co-ordinate the work of those who are willing to co-operate to that extent.

Sulphidizing and Flotation of Oxidized Ores

Flotation of oxidized minerals depends upon a preliminary "sulphidizing" by any method that will convert at least the surface of the mineral particles to a sulphide of the metal. This step is followed by flotation of the "artificial" sulphide, which results in a concentration of the metallic values in the low-grade oxidized ore being treated.

The methods of sulphidizing that have been investigated are as follows:

Sulphidizing (1) by the use of hydrogen sulphide on either the dry or the wet crushed ore; (2) by the use of solutions of the various sulphides and sulfo-compounds of sodium; (3) by the use of solutions of the various sulphides and sulfo-compounds of calcium; (4) by the use of sulphur vapor; (5) by the use of a sulphureted oil; (6) with colloidal sulphur.

It has been found that treatment by some of these methods will form a film of sulphide over the surface of the particles of such minerals as lead carbonate or copper carbonate, whereas in other cases the mineral particles are sulphidized to the core. Other methods failed to give any results.

CARBONATE OF LEAD ORES

All of the above methods of sulphidizing have been tested on a great number of carbonate-of-lead ores. Some of these ores contained silver and some contained lead as the principal metal. A number of the ores have been successfully concentrated and others refuse to yield to concentration by flotation. In general, a high alumina content (acid soluble) in an ore seems to prevent the application of sulphidizing and flotation. The purpose of this report is to give the main features of the flotation of oxidized ores of lead, as well as other ores.

In sulphidizing with hydrogen sulphide gas, as applied to the lead carbonate ores, it was found that the best method of applying the gas to a dry powdered ore was in a tumbling barrel with the gas inlet in the end. Sulphidizing in a glass bottle showed that the ore blackened quickly after the application of the hydrogen sulphide gas. On attempting to float out lead sulphide from the ore as soon as it had blackened it was found that a low extraction of lead was obtained and likewise a low-grade concentrate, unless the pulp was previously acidified with sulphuric acid. By acidifying the pulp, cleaner concentrates were floated but the extractions of lead remained low. Only by prolonged treatment with hydrogen sulphide gas could the extraction of the lead be raised to commercial grade. With a number of ores eight hours' treatment gave an extraction of over 80 per cent of the lead.

The use of hydrogen sulphide was considered for the reason that it can be generated quite cheaply. With iron matte available at \$5 to \$10 per ton, and sulphuric acid from \$5 to \$10 per ton, the cost of the hydrogen sulphide resulting, including labor, etc., is between \$30 and \$50 per ton. If this gas in combining with the metal in the ore produces only a superficial film of sulphide, and does not penetrate to the center of the particles, it might be possible to make a ton of the gas sulphidize many tons of ore.

Unfortunately hydrogen sulphide attacks the metallic particles of the ore with such avidity that by the time the latter are sulphidized sufficiently to permit of good extraction by flotation, they have also been sulphidized to the core, and practically a chemical equivalent of hydrogen sulphide, to the lead in the ore, has been absorbed. Even coarse pieces of ore in a bottle absorb the gas with evolution of heat, and on breaking open the pieces the black coloration is seen to have traveled deeply into the particles.

Owing to the fact that the value of the lead concentrate obtained is very low as compared to the amount of hydrogen sulphide necessary to sulphidize it, this process is not regarded as commercially practicable.

Application of hydrogen sulphide to the ground ore suspended in water does not seem to be subject to the same difficulty. True "filming" of the particles with a film of lead sulphide seems to take place, and the extractions possible after a short treatment with the gas are satisfactory. The speed of travel of molecules of hydrogen sulphide gas, as compared with the speed of travel of the same molecules in solution affords an explanation of the difference in the action of the gas when applied to dry pulverized ore as compared to its action when applied to pulp suspended with water.

The best results on lead carbonate ores have been obtained when sulphides of sodium were used for the sulphidizing agent. The sodium sulphide must necessarily be introduced in solution and seems to cause true filming. The sulphides of sodium considered commercially applicable are the normal sulphide of sodium, Na_2S ; sodium polysulphides, Na_2S_x and Na_2S_y , and the sulphhydrate of sodium, NaSH . Of these the latter, the sulphhydrate, seems to be very effective, as is evidenced by the quicker blackening of the pulp, and the deeper, blacker color formed. The normal sulphide is almost as effective; the polysulphides seem to be the least active. Different ores require 10 minutes to 24 hours of contact with the solutions of sodium sulphide used, depending on the properties of the ore and on the strength of the solution of sodium sulphide. Amounts of sodium sulphide varying from 10 to 20 pounds per ton of ore are usually sufficient, and should be applied to pulp containing about one ton of water per ton of ore, in order that the solution may be as strong as possible during

*A report issued by the Bureau of Mines, under the direction of the Director.

the sulphidizing stage of the process. After a good black color has developed, and the color has ceased to increase in blackness, the pulp is diluted with water to a 3:1 or 4:1 mixture and floated in either mechanically agitated or pneumatic machines. The market for sodium sulphide is limited, and it should be obtainable at considerably less than 2 cents per pound.

The polysulphide of calcium, obtained by boiling powdered sulphur with slacked lime, seems to be satisfactory for ores that yield easily to sulphidizing, but is sluggish in its action, as compared to the sulphides of sodium. The normal sulphide of calcium is only slightly soluble, and hence its use was discontinued as a possible sulphidizing agent. The sulphhydrate of calcium is the most active of these reagents, but has not been tested to any extent in this work, as there is doubt as to whether it would be commercially feasible to prepare such a compound.

Sulphidizing with sulphur vapor has been tried with little success, for the reason that it must be applied at a temperature above the boiling point of sulphur in order to prevent condensation of the sulphur. This means that the ore must be heated to a temperature above 445° C. There seems to be no difficulty in obtaining elemental sulphur vapor commercially, as pyrite will give up half of its sulphur content when heated in a closed space, and sulphur dioxide gas can be reduced to elemental sulphur by passing it through a heated zone in the presence of a reducing agent. As lead itself is easily reduced from its carbonate form, the temperature might as well be raised to the point where the lead can be liquated out, a reducing atmosphere being used instead of a sulphidizing atmosphere.

The use of a sulphureted flotation oil, in which loosely combined sulphur is available for combination with carbonates of lead or other metals, and the rest of the oil is then available for "oiling" the artificial sulphide, has given very little encouragement in the tests conducted by the bureau.

Finally colloidal sulphur, mentioned as a possible method of sulphidizing, does not seem to combine with lead carbonate at all. It floats as a white lining of the air bubbles in the flotation machine, and brings up very little lead with it.

Usually the precious metals contained in a lead carbonate ore accompany the lead. The writers have noticed that the silver extraction will lag behind the lead extraction when the ore is sulphidized with sodium sulphide, and that the reverse has usually been true when hydrogen sulphide was used.

The importance of sulphidizing flotation is due to the fact that there are many deposits of lead carbonate ore in all of the Western States, and many of these ores have been milled with varying success. Frequently the lead carbonate can be satisfactorily concentrated by gravity methods, but often it is found that the particles of lead carbonate go into the slimes and are lost. Tailing heaps containing 5 to 10 per cent of lead are common. The object of this investigation is to determine whether sulphidizing flotation could not be applied to the treatment of the deposits of lead carbonate above mentioned, to prevent the waste that now takes place when these ores are treated by gravity concentration processes, and render amenable to treatment carbonate ores that are too low grade to be treated by present methods.

The General Engineering Co., of Salt Lake City, Utah, has carried on extensive tests of different lead carbonate ores with varying success, according to the ore tested. The company owns several sulphidizing patents, which it has either patented or purchased.

A flotation plant to apply sulphidizing and flotation

to an ore containing lead, silver and gold is being constructed by the Prince Consolidated Mining Co. at Pioche, Nev., for the treatment of two tailing dumps from former pan-amalgamation and cyanide operations in that vicinity. This plant was expected to be in operation by July 1, 1916.

OXIDIZED COPPER ORES

Many attempts have been made, both by large operating companies and by other experimenters, to float the carbonate and other oxidized minerals of copper. For that reason the testing of such ores by the writers has been limited.

Hydrogen sulphide seems to be by far the best medium for sulphidizing oxidized copper ores previous to flotation. When applied to the dry ore, the writers found the same conditions as those mentioned for lead; the particles are sulphidized to the center, which requires an excessive amount of hydrogen sulphide. Applied to the wet pulp, the hydrogen sulphide seems to cause true filming. The writers' work has yielded black concentrates, but they are informed by Mr. Callow of the General Engineering Co. that the company has been able to reduce the amount of sulphur used to a point where the froth is green with slightly coated malachite. He states that as little as one-half pound of sulphur per ton of ore is giving good extractions in the plant of the Magma Copper Co., at Magma, Ariz., where his company has put in the first successful installation of this kind.

Sodium sulphide has been tested by a number of the larger companies who have some oxidized copper minerals in their sulphide ores. The amount of oxidized copper in such ores is usually a fraction of 1 per cent, so that two or three pounds of sodium sulphide per ton of ore are all that is necessary. This is usually added to the machines during flotation, or to the mixing tanks before flotation. The writers' experience is that if some little time of preliminary contact is allowed before flotation is attempted, better sulphidizing of the material will result.

Calcium polysulphide has been used for some time in a number of the large copper concentrating mills with indifferent success, and seems to be detrimental in some instances. On the ores tested by the writers fair results were obtained if the calcium polysulphide was allowed to act until the ore had become well blackened.

It is stated that sulphur vapor was tested at one of the large plants for flotation of oxidized forms of copper and gave better results than any other method of sulphidizing. Of course this method has the disadvantage of having to be applied to dried, heated and finely divided ore.

Sulphureted oils are being used at a number of plants to supplement other methods of sulphidizing and considerable secrecy is observed as to the technical details of this work.

So far as the writers know, colloidal sulphur does not assist in the flotation of oxidized forms of copper. Neither has the silicate of copper been successfully floated by sulphidizing flotation. It will blacken when sulphidized, but resists flotation. Possibly it still presents a silicate surface, rather than a sulphide surface to the flotation elements. For this reason a number of the large copper companies are seriously contemplating leaching the oxidized copper ores, rather than lose what silicate of copper may be present.

Repeated attempts to float the natural sulphides along with sulphidized minerals have failed, as the sulphidizing agents cause trouble with the flotation of the natural sulphides. By careful adjustment this difficulty has

been solved in one plant, though the details are not available.

OXIDIZED ZINC MINERALS

Attempts to float the oxidized particles of zinc from their ores, both before and after sulphidizing by most of the above methods, have met with no success whatever in the laboratory experiments of the writers. They are informed that some headway was made with the problem by Professor Traphagen, at the Colorado School of Mines, but that the sulphide film seemed to come off too easily. However, poor results were obtained, whatever the cause.

The writer's experience has been that most of the carbonate ores of zinc contain important amounts of the silicate, and this may be one reason for the non-success of this work, for the same reasons that copper silicate will not float.

Direct flotation of oxidized minerals of the kind mentioned, so far as known, has not been successfully accomplished. In all of the successful work witnessed by the writers there has been some form of alteration of the oxide to the sulphide. A number of parties claim to be successful in the flotation of copper carbonates without sulphidizing, and others in the flotation of scheelite, fluorite and magnetite. The authors were unable to verify these statements.

Results of Tests

Some of the best results and some average results which have been obtained in the work at the Utah station are given in the table following.

RESULTS OF SULPHIDIZING AND FLOTATION OF OXIDIZED ORES										
LEAD-SILVER ORE										
Ore No.	Source of Ore	METAL CONTENT OF ORE			METAL CONTENT OF CONCENTRATE			EXTRACTION		
		Lead, per Cent	Silver, Ounces	Gold, per Cent	Lead, per Cent	Silver, Ounces	Gold, per Cent	Lead, per Cent	Silver, per Cent	Gold, per Cent
1	Daly Judge mine, Utah	16.1	20.6	3.6	41.5	8.1	8.0	8.1	8.0	8.0
2	May Day mine, Utah	4.0	2.2	36	24.6	9.6	55	55	55	55
3	May Day mine, Utah	4.5	2.2	25.4	12.04	5.2	4	5.2	4	4
4	May Day mine, Utah	4.5	2.2	2.1	11.5	5.2	48	5.2	48	48
LEAD ORE										
Ore No.	Source of Ore	Lead, per Cent			Lead, per Cent			Lead, per Cent		
		Lead, per Cent	Silver, Ounces	Gold, per Cent	Lead, per Cent	Silver, Ounces	Gold, per Cent	Lead, per Cent	Silver, per Cent	Gold, per Cent
5	Wilbert Mill dump, Idaho	5.77	28.2	74	5.77	28.2	74	5.77	28.2	74
6	Seranton Mine, Utah	8.74	65.0	88	8.74	65.0	88	8.74	65.0	88
LEAD-SILVER-GOLD ORE										
Ore No.	Source of Ore	Lead, per Cent	Silver, Ounces	Gold, Ounces	Lead, per Cent	Silver, Ounces	Gold, Ounces	Lead, per Cent	Silver, per Cent	Gold, per Cent
		Lead, per Cent	Silver, Ounces	Gold, Ounces	Lead, per Cent	Silver, Ounces	Gold, Ounces	Lead, per Cent	Silver, per Cent	Gold, per Cent
7	Shattuck mine, Ariz.	15.42	12.88	0.05	48	45.2	0.128	8.8	75	75
COPPER-SILVER-GOLD ORE										
Ore No.	Source of Ore	Copper, per Cent	Silver, Ounces	Gold, Ounces	Copper, per Cent	Silver, Ounces	Gold, Ounces	Copper, per Cent	Silver, per Cent	Gold, per Cent
		Copper, per Cent	Silver, Ounces	Gold, Ounces	Copper, per Cent	Silver, Ounces	Gold, Ounces	Copper, per Cent	Silver, per Cent	Gold, per Cent
8	Grand Central mine, Utah	0.60	4.80	0.22	1.75	32.9	1.28	67	75	75
ZINC ORE										
Ore No.	Source of Ore	Zinc, per Cent	Zinc, per Cent	Zinc, per Cent	Zinc, per Cent	Zinc, per Cent	Zinc, per Cent	Zinc, per Cent	Zinc, per Cent	Zinc, per Cent
		Zinc, per Cent	Zinc, per Cent	Zinc, per Cent	Zinc, per Cent	Zinc, per Cent	Zinc, per Cent	Zinc, per Cent	Zinc, per Cent	Zinc, per Cent
9	Honorine mine, Utah	28.45	27.2	Nil	28.45	27.2	Nil	28.45	27.2	Nil

METHOD OF SULPHIDIZING

Ore 1.—Two hours' treatment with H_2S gas on dry ore.

Ore 2.—Four hours' treatment with H_2S gas on dry ore.

Ore 3.—Eighteen hours' treatment with 1 per cent solution of Na_2S , 20 lb. per ton of ore.

Ore 4.—Three hours' treatment with 0.8 per cent solution of CaS , 16 lb. per ton of ore.

Ore 5.—Four hours' treatment with 1 per cent solution of Na_2S , 20 lb. per ton of ore.

Ore 6.—One-half hours' treatment with 6 per cent solution of Na_2S , 12 lb. per ton of ore.

Ore 7.—One-half hours' treatment with 0.75 per cent solution of Na_2S , 15 lb. per ton of ore.

Ore 8.—Short-time treatment with hot 1 per cent solution of Na_2S , 20 lb. per ton of ore.

Ore 9.— Na_2S or H_2S in various amounts.

PATENTS ON SULPHIDIZING AND FLOTATION PROCESSES

A list of patents dealing with methods of sulphidizing and flotation follows:

U. S. Patent	807,501	June 1, 1915	H. C. Bacon
U. S. Patent	1,094,760	April 29, 1914	H. C. Bacon
U. S. Patent	1,095,668	May 25, 1915	H. C. Bacon
U. S. Patent	1,140,885	May 25, 1915	H. C. Bacon
U. S. Patent	1,140,966	May 25, 1915	H. C. Bacon
U. S. Patent	1,159,942	Nov. 9, 1915	H. C. Bacon
U. S. Patent	1,180,816	April 25, 1916	H. C. Bacon
British Patent	26,019	Nov. 10, 1909	H. C. Bacon

(Note.—Provisional specifications 28,612, Sulman and Picard, applied for Dec. 7, 1909, and 29,616, applied for Dec. 17, 1909, are incorporated in British Patent 26,019.)

Synopsis of Recent Chemical and Metallurgical Literature

Gold and Silver

Gold Dredge.—What is reported to be the largest ladder dredging unit thus far constructed is described in *Engineering Record*, June 24. The hull was launched at Hammonton, Cal., in April. It is equipped with an endless chain of 100 buckets, each of 16 cu. ft. capacity. Material is to be excavated from a depth of 82 ft. below water level. The monthly capacity is 300,000 cu. yd. of material, and this yardage is handled with a crew of but three men. The dredge is operated by a 400-hp. motor for driving the excavator, and six other motors ranging from 35 to 150 hp. The hull is built of structural steel and weighs about 1000 tons without mechanical equipment. This dredge is to be operated on the Yuba River by the Yuba Consolidated Gold Fields Company, and is to be duplicated by a sister dredge to be launched this fall.

Copper

Dust Losses at Copper Queen Reduction Works.

In an elaborate paper prepared by Mr. J. MOORE SAMUEL of Douglas, Ariz., for the September meeting of the American Institute of Mining Engineers, the author gives the results of measuring dust losses from blast furnaces, converters and roasters at the Copper Queen smelter. The following essentials of a suitable method for determining such losses are laid down:

1. The sample of gas taken for filtration must be representative of the whole volume of gas, that is to say, it must have the same dust content. This condition will be fulfilled in all cases if the gas sample is drawn off without change of rate of flow. Then it will contain the same proportion of entrained or suspended particles of dust as the original gas. In the case of flue gases which contain only fume, at a temperature above or near the sublimation point, this condition need not be adhered to since the fume will not behave as entrained particles, but more nearly as a true gas. Consequently the gas sample in this case only may be drawn off at any rate of flow.

2. The gas sample taken must be large enough (a) to yield sufficient dust to permit of accurate chemical and physical examination; (b) so that the ratio of the total volume of gas passing through the flue to the volume of gas sample taken, shall not be too large.

3. The methods of measurement of gas volumes should be such that an occasional independent check can be made.

After describing in some detail the methods employed, which can be best obtained from the original paper and the tabulated results and drawings, the author gives some condensed data on the improvements secured through changes in practice suggested by the tests.

In 1909 when the tests were started, the equipment consisted of five 42 x 240-in. and five 42 x 216-in. blast furnaces and eight acid-lined converters of barrel type, 8 x 11 ft. Following these original tests an experimental settling chamber of 23 sq. ft. cross-sectional area and 50 ft. long was erected to make tests of dust settling at different rates of gas flow. Later this test chamber was lengthened to 100 ft. As a result of the experiments it was concluded that flues or settling chambers need not be longer than 125 ft. if the gas velocity did not exceed 150 ft. per minute, and that this velocity could be exceeded if wires or screens were placed in across the direction of flow. The dust chamber was subsequently enlarged to conform to these conclusions, and further tests were made. Comparing the results obtained with previous tests made under the same operating conditions, there is a decrease in dust loss of 103,800 lb. per day (from 164,680 to 60,860), and in the copper loss of 10,800 lb. per day (16,142 to 5355). That is a decrease of 63 per cent of dust loss and of 67 per cent of the copper loss.

In 1913, after the reverberatory and roaster plant had been blown in, the fine ore was no longer charged into the blast furnaces. Another series of tests was made under these conditions which shows a further decrease, the dust loss being 40,000 as against 60,000, and the copper loss 2589 as against 5355. It should be noted, however, that one less blast furnace was in operation.

Reverberatory dust losses are probably nominal and have not been determined.

The roaster losses have been determined under the following different conditions of operation:

Roasters in Operation	Draft	Feed
1	Low	Fine
2	Mixed	Mixed
3	High	Mixed
4	Low	Mixed
(5)	Low	Coarse

The roaster plant consists of sixteen six-hearth McDougall roasters, 18 ft. in diameter. The flue is 144 ft. long with a free cross-sectional area of 1235 sq. ft. Wires are hung in all but the first and last 12 ft. of the flue, or in a total length of 120 ft. From the tabulated results of roaster dust losses we note the following:

Roaster Feed	Tonnage of Charge Received in 24 Hr.	Dust Loss			Metal Loss in 24 Hr.			Draft at End of In- flue Dust Chamber Cubic Feet of Air per Minute
		Lb. per 24 Hr.	Per Cent of Charge	Grains of Dust per Cubic Foot of Gas	Gold, Oz.	Silver, Oz.	Copper, Lb.	
Pyrite	94	10,160	1.14	0.250		17.6	605	0.15 to 0.20
Pyrite and sulphate	752	52,704	3.508	0.894	0.75	101.7	4,388	0.21 to 0.28
Pyrite and sulphate	795	71,940	3.525	1.077	1.60	132.5	5,941	0.40 to 0.50
Pyrite	1,800	62,000	3.831	1.072	0.66	111.9	5,308	0.26 to 0.30
Sulphide ore	576	25,950	2.243	0.458	0.50	20.5	1,726	0.26 to 0.30

The roaster dust loss seems to depend on the tonnage treated by the roasters, the roaster draft, and the size of the particles fed. It is found in practice that the roaster draft has a great effect on the capacity of the furnaces, but our tests also show that increase of draft, or increase of tonnage treated, result in prohibitive dust losses, so that now the roaster draft is kept at

the absolute minimum which is required to carry away the gases.

Pumping

Pumping Costs with Diesel Engines.—Some interesting data on pumping water with Diesel engines is given by H. W. GOCHNAUER of Appleton, Wis., in the June 3rd issue of *Engineering Record*. For the year ended April 1, 1916, these engines pumped at an oil cost of \$2.82 per million gallons, against a head of 185 ft. The installation consists of two 225-brake-hp. three-cylinder, four-stroke Diesel oil engines. Each engine is direct-connected to two Deane double-acting triplex pumps of 2,000,000-gal. capacity each. In addition to pumping water the engines operated two 15-kw. 110-volt D.C. generators for lighting, without sensibly increasing the fuel-oil consumption. The operating labor consists of a chief engineer and three assistants, who work in two two-man shifts. For the year indicated the engines were operated 5948 hr., consuming 44,610 gal. of oil and pumping 569.43 million gallons of water. The fuel-oil average consumption per million gallons of water pumped was 78.6. Fuel oil cost 3.6c. per gallon, or \$2.82 per million gallons; lubricating oil, 36c.; labor, \$6.48; materials, \$1.98; total, \$11.64 per million gallons.

The efficiency of an air-lift is reported in the same issue of the *Engineering Record*. Total depth of well, 120 ft.; diameter, 8 in.; depth to foot-piece, 106 ft.; foot-piece to umbrella, 115.5 ft.; water eduction pipe, 5 in.; air pipe, 1 1/4 in. The lift developed an efficiency of 59.6 per cent measured between the steam end of the compressor and the point of delivery of the water. Air consumption was 50 cu. ft. free air per minute. The curve of efficiency shows a steady falling off as the pressure is increased and more water pumped. Thus with 100 cu. ft. free air per minute, pumping 392 gal. per minute, the efficiency was only 40.2 per cent. This decrease is expected for two reasons: First, because of the lower submergence when pumping the larger quantity; second, because of the greatly increased friction of water and consequently slippage of air at the higher velocities of discharge. This friction and slip is held to be the greatest contributing cause of inefficiency in air-lifts.

Power and Transportation

Diesel Engines vs. Steam Turbines for Mine Power Plants.—In a paper to be presented at the Arizona meeting of the American Institute of Mining Engineers, Mr. HERBERT HAAS of San Francisco discusses the subject of cheap power for mining and metallurgical plants, and gives some comparative data on Diesel engines and steam turbines. The supply of cold water for condensing purposes is a factor of importance, since about twelve times as much water will be required for condensing purposes with steam turbines under general conditions as is needed for jacket-cooling of two-stroke cycle Diesel engine; four-stroke cycle Diesel engines require only one-twentieth of the cooling water. Another condition favoring the use of Diesel engines is the high load factor at which most mine power plants operate.

The author tabulates the cost of producing power with (a) four 3000 B.h.p. (2000 kw.) Sulzer Diesel engines direct-connected to alternators and exciters, and (b) with two 6000-kw. steam turbines. For a plant of each type costing \$720,000 and fixing usual costs for labor, maintenance (1 per cent cost of installation per year), interest and amortization, and fuel oil at \$1.25 per barrel of 320 lb., the following comparative cost data are deduced:

	8000 Kw.		6000 Kw.		4000 Kw.		2000 Kw.	
	Per Kw.-yr. Doll.	Per Kw.-hr. Cts.	Per Kw.-yr. Doll.	Per Kw.-hr. Cts.	Per Kw.-yr. Doll.	Per Kw.-hr. Cts.	Per Kw.-yr. Doll.	Per Kw.-hr. Cts.
Diesel engine	39.81	0.4515	44.51	0.5081	53.89	0.6152	83.96	0.9256
Steam turbine	61.75	0.7051	63.50	0.7230	76.60	0.8746	111.70	1.2778

In general, the selection of either type of prime mover will be governed by the following economic considerations:

1. Fuel is of chief influence on the total power cost where both the B.t.u. price and load factor are high. These conditions favor the use of the Diesel engine.

2. Interest and redemption (amortization) are of chief influence on the total power cost with low B.t.u. price and low load factor; this applies particularly to stand-by plants, which are operated only occasionally or have to supply recurring peak loads. The installation cost of such plants must be kept as low as possible so as to avoid heavy capital charges distributable over a relatively small kilowatt-hours output of the station. Such conditions favor the steam turbine.

3. Exceptions to (2) are cases where the constant and instant readiness of the Diesel engine give it preference, and installation cost is of secondary importance. Here we would have to balance the cost of keeping boilers under steam continuously against the difference of interest charges of steam-turbine and Diesel engine plants.

4. Power plants located at the source of the fuel, either in the oil fields, or at the coal mine, and therefore enjoying the advantages of a very cheap fuel supply, will select prime movers costing least to install, i.e., steam turbines, since fuel expenditures will weigh less than interest and redemption charges.

5. In many cases combination plants using Diesel engines for supplying the continuous and nearly constant main load, and steam turbines for furnishing periodically occurring peaks by the use of high-duty boilers with large water and steam spaces, capable of being forced when necessary, will prove most profitable. Thus, as an example, the periodical peaks produced in hoisting may be taken care of by a turbine floating on the line and operating in parallel with Diesel engines that supply the main load and operate constantly at or near full load.

6. Steam power will remain the cheapest power wherever waste-heat gases are available, as for instance gases from reverberatory smelting furnaces, where nearly one-half of the fuel used in smelting can be utilized for steam generation. Nearly 3,000,000 B.t.u. for every ton of charge smelted are thus available for steam generation, or about 150 hp.-hr. per ton of charge which is smelted.

7. Up to capacities of 1000-hp. steam turbines can compete with Diesel engines only in special cases, such as supplying exhaust steam for heating purposes. For such small units, particularly for greatly varying loads, high-grade reciprocating steam engines are preferable. For larger plants, from 1000 to 10,000 kw. capacity, careful analysis must be made of the relative advantages of Diesel engines and turbines, a knowledge of the load factor, fuel prices and water conditions being necessary. Power plants larger than 10,000 kw. using units from 6000 kw. upward, preferably use steam turbines, unless a combination of high load factor, high fuel cost, and poor water conditions favor a Diesel plant. This is a special condition frequently met with in actual practice.

Recent Chemical and Metallurgical Patents

Iron and Steel

Opening Frozen Tap-Holes.—A method of opening frozen tap-holes of blast or open-hearth furnaces, patented by HENRY C. WITZ, of Johnstown, Pa., consists in applying a heated iron bar to the hard or frozen metal in the tap and continuously feeding oxygen to the heated bar so as to maintain the latter in an incandescent condition and thus enable it to eat its way through the frozen crust. (1,186,358, June 6, 1916.)

Treatment of Ores to Produce Alloys.—The direct production of an alloy of iron and nickel, or iron and any other metal such as manganese which may be contained in iron ores, is patented by FREDERICK A. EUSTIS, of Milton, Mass., and CHARLES P. PERIN of New York City, and assigned to the Moa Bay Iron Co. The object is to avoid the separate extraction of one of the contained metals when it is possible to obtain a desirable alloy by direct reduction. Considering the case of Cuban iron ore containing about 1 per cent of nickel, a parcel of ore is divided into two parts, one of which is to be treated for the extraction of a predetermined amount of its nickel which is subsequently added to the second part, thereby enriching the mixture in nickel, whereupon the mixture is smelted to produce an iron-nickel alloy. The treatment of the first part of the ore for extraction of nickel may be accomplished by roasting with sulphur-bearing material, yielding a sulphated product from which nickel sulphate can be leached. The nickel solution thus obtained may be precipitated, and the precipitate added to the second part of the ore prior to smelting. Various modifications of the method are given. (1,185,187, May 30, 1916.)

Copper, Lead and Zinc

Process of Refining Copper.—A substitute for the ordinary method of refining copper by oxidizing and then reducing with poles is patented by EDWARD C. KING, of Cananea, Mex. His method consists essentially in introducing hydrocarbon oil under suitable pressure into a bath of molten copper. He claims that the oil not only acts to eliminate gaseous or metallic impurities, forming a slag of the latter, but after all the impurities except oxygen have been removed, continuation of the operation will ultimately expel oxygen and give a refined copper. (1,183,736, May 16, 1916.)

Hydrometallurgy of Lead and Zinc Ores.—A method of treating lead and zinc sulphide ores by roasting and leaching with a chloride solution is patented by ROYAL S. HANDY, of the Bunker Hill & Sullivan Company, Kellogg, Idaho. The roast is conducted so as to yield as much lead sulphate as possible, after which the material is agitated with hot sodium chloride solution. Lead goes into solution as chloride, and when the solution cools much of the lead salt crystallizes out, while the solution can be used again or diverted to a regenerating system. Any unconverted sulphides remaining in the roasted material may be recovered by leaching with ferric chloride, whereby chlorides of the metals are obtained and precipitated on suitable metals: lead on iron, silver on lead, etc. The zinc solution may be electrolyzed. (1,185,902, June 6, 1916.)

Dry Chloridizing of Sulphide Ores.—In a patent issued to JOHN L. MALM, of Denver, Colo., the inventor discloses his method of treating sulphide ores of lead, zinc and iron, with dry chlorine gas, rendering the iron insoluble and the other metals soluble. The essential apparatus includes a tube-mill, a roasting furnace and an agitating machine. The dry ore is introduced into the tube-mill where it is subjected to the action of dry chlorine gas. Reaction proceeds to a point of par-

tial chloridization of the valuable metals and the formation of either ferrous or ferric chloride. The partly chloridized mass is then passed to the roasting furnace where chloridization is completed by the decomposition of the iron chloride, forming inert iron and manganese compounds and yielding chlorine to complete the chloridizing of the other metals. The latter are thus rendered soluble, and separation from iron and manganese offers no difficulty. Any gold and silver in the ore may be recovered by cyanidation or amalgamation after the pulp is agitated with the leaching solution and filtered. The leaching solution is hot water, which takes up the chlorides of lead, copper and zinc, leaving the inert iron and manganese compounds behind. (1,185,817, June 6, 1916.)

Electrolytic Apparatus.—An electrolytic cell in which the anodes are placed vertically above the cathodes is shown in Fig. 1, being the patented invention of WILLIAM E. GREENAWALT, of Denver, Colo. Another feature of the cell is the anode bell which collects the anode gases, either chlorine or oxygen, depending on whether copper chloride or sulphate is electrolyzed. The oxygen thus formed may be removed for the treatment

bleaching powder is added to effect oxidation of iron and manganese. These metals separate in gelatinous form, but small amounts remain in colloidal form, difficult of separation. These are then removed by boiling with hydrated silicic acid, formed by neutralizing sodium silicate with a mineral acid. When the neutralization is effected and the solution heated, insoluble silica is precipitated and carries down with it the remaining traces of iron and manganese. From the pure zinc sulphate solution thus prepared, zinc oxide or metal can be formed by appropriate means. (1,185,757, June 6, 1916.)

Treatment of Flue-Dust.—In Fig. 2 is given a diagram of a method of treating flue-dust from roasting or blast furnaces, according to the specifications of a patent granted to FRANCIS C. RYAN, of Hammond, Ind. The material is first leached with hot water to extract

all water-soluble compounds, such as the sulphates of zinc, arsenic and iron. The leach liquor is blown with air to oxidize the iron in particular. The residue is sulphated by roasting with sulphuric acid, the excess of which aids in the solution of basic anhydrous salts of iron, copper, zinc, etc. The roasted material is boiled with a limited amount of water, and the sulphate solution of silver, copper, zinc and iron is separated by filtration. To it is added the water solution first obtained, and the whole is precipitated with zinc oxide, throwing down iron, bismuth, arsenic, antimony, selenium and tellurium, while the sulphates of silver, copper, zinc and cadmium remain in solution. Precipitate and solution are separated, and treated for the recovery of their metallic contents by acceptable metallurgical methods. 1,182,320, May 9, 1916.)

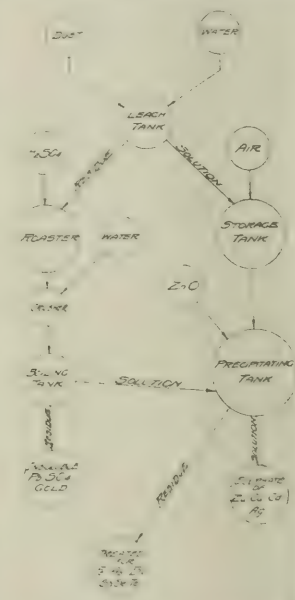


FIG. 2—TREATMENT OF FLUE DUST

of ore by cyanidation, in which process oxidation plays an important part. Since the oxygen obtained from electrolysis at high current densities contains much ozone, the gas has an enhanced oxidizing power. Referring to the figure, 1 represents a shallow tank mounted on wheels; 4 is an inverted tank or anode bell suspended by suitable means as shown and dipping below the electrolyte in the cell. The cathodes are represented at 6 and the anodes at 7. Connections for anodes and cathodes are shown at 9 and 10, and inlet and outlet for solution at 11 and 12. Since the anodes are placed vertically over the cathodes, the anode gases will rise through the electrolyte into the anode bell and will not come in contact with the deposited metal at the cathode. The rising of the anode gases and the prevention of short-circuiting is facilitated by the oscillation of the anode bell, which has a small amplitude of vibration. (1,183,188, May 16, 1916.)

Hydrometallurgy of Zinc Ores.—A method of preparing pure zinc sulphate solution from zinc ores, particularly from roasted silicate zinc ores, is patented by SHUNJIRO ARAKI, of Osaka, Japan. The pulverized roasted ore is treated with the chemical equivalent of a 20 per cent sodium bisulphate solution, dissolving the zinc, together with lead, copper and small quantities of iron and manganese. The solution is filtered and treated with zinc in the form of dust or sheets to remove the copper and lead. The solution is next neutralized with caustic alkali, and an oxidizing agent like

bleaching powder is added to effect oxidation of iron and manganese. These metals separate in gelatinous form, but small amounts remain in colloidal form, difficult of separation. These are then removed by boiling with hydrated silicic acid, formed by neutralizing sodium silicate with a mineral acid. When the neutralization is effected and the solution heated, insoluble silica is precipitated and carries down with it the remaining traces of iron and manganese. From the pure zinc sulphate solution thus prepared, zinc oxide or metal can be formed by appropriate means. (1,185,757, June 6, 1916.)

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New Development in Castings of a Heat-Resisting and Non-Corroding Alloy

It is well known that there are very few metals or alloys which are suitable for working at temperatures between 1750 to 1800 deg. Fahr., without losing their strength rapidly, being volatilized or melting completely, and at the present time there is nothing in this line generally commercially available for industrial purposes.

The Driver-Harris Wire Co., Harrison, N. J., manufacturers of the nickel-chromium alloy "nichrome," which is well known in the electrical trades throughout the world as a resistor, has been, for some time past, developing this product in the form of castings and this research has been quite successful and remarkably interesting results have been achieved; the most important of which is, no doubt, the demonstration and practical service with extreme long life of "nichrome" in the cast form, compared with iron for work at high temperatures.

The company has been manufacturing these castings now for about a year and they are used in a great variety of different lines of industrial work. Patents have been assigned to the company by Mr. John C. Henderson, an engineer of the company, for the manufacture of these castings.

One of the new cast products of "nichrome," which has found much favor among manufacturers, especially in the automobile industry, is the carburizing box, used for heat-treating many different kinds of steel parts.



HEAT-TREATING BOXES OF NICHROME

Among the advantages which we note casually in this product, over the cast-iron box, are the following:

It possesses the characteristics of retaining its strength, as well as its shape, at high temperatures and does not become distorted, warp or bulge, as in the case of the iron boxes.

Marked economy is noted through saving in time, as the "nichrome" box may be quenched in water while red hot, thus saving the space and handling of reserved iron boxes.

Due to its far greater durability it may be made one-half the thickness of the iron box and thus save considerable labor in handling. These boxes may be had with walls cast $\frac{5}{16}$ in. to $\frac{1}{2}$ in.

Due to the fact that the box retains its strength and does not bulge the capacity of the furnace and tonnage of the product treated are increased appreciably. In the case of iron boxes it is a common thing to see the box cave in or warp badly. Another important advantage which should not be overlooked on this cast box, is the economy through long life, as the box loses very little of its tensile strength at working temperature of 1750 to 1800 deg. Fahr.

Among the cast products of the alloy, we find the much used pyrometer protection tube. This type of tube is now used very extensively and it is rapidly displacing the porcelain tube, which is fragile and very easily broken. In one case the tubes showed a life of 4000 hours.

It may be well to mention that a very interesting line of research is being conducted on metal crucibles of nichrome. Indications now are that these crucibles will very materially change the present practice in the melting of copper, brass and similar materials. Some very interesting results have been obtained from crucibles made to hold up to 175 lb. of metal and various metals have been melted to observe the effect which they had on the crucible. Brass, copper and phosphor copper have been melted, without the crucible showing any signs of deterioration. This is very important when we consider that phosphor copper has a corroding action on most all types of crucibles.

The writer saw one nichrome crucible in which phosphor-copper had been melted and which had been placed in white-hot coke and which had been used in oil vapors and other kinds of fire. About 50 heats had been made in this crucible and no signs of deterioration were visible. The nichrome crucible possesses the desirable property of not "alloying."

Tests made in No. 40 to No. 50 crucibles (the crucibles hold about 3 lb. to a number, thus No. 50 holds about 150 lb.), showed that metals could be melted quickly. Melts were made in about 40 minutes and required no especially careful handling or preliminary seasoning. The tests on the crucibles have not been entirely completed and it will be some time before the company will place them generally on the market.

Among other interesting products which have been made is a skimming ladle to be used in connection with a brass pot. When the brass pot is poured, the ladle is held in the neck of the pot, to keep back any dross or foreign substance floating on the top. Furnace bottoms, supporting frames, furnace floors to cover the fire bricks in heat-treating furnaces and in the chains and conveying parts of the continuous furnaces are other interesting uses. Furnace nozzles for oil burning have been tried out successfully, glass molds are being experimented with and a large pot for lead hardening and cyanide hardening has also been tested and has been found to offer many advantages. Some sections of pipe 15 in. in diameter and about 12 in. long have also been made.

It might be well to mention some of the other properties of nichrome as they should prove of general interest. In using nichrome wire baskets for pickling purposes and for heat-treating work, one of these baskets was used for six months in acid-dipping in which it was subjected to 40 deg. nitric acid, 40 deg. muriatic acid and 66 deg. oil of vitriol, also a mixture of several acids. No signs of the metal being affected were apparent. An ordinary brass basket lasted only four to six weeks at the same sort of work. In another case, a basket for heat-treating work was run through an annealing furnace at 1400 deg. Fahr. and dipped hot in 1:4 sulphuric acid. This process was carried on 140 times without any effect on the basket.

Nichrome can be readily machined, requiring no special tools. It has a tensile strength about twice that of ordinary cast iron and about the same hardness.

The development of these heat-resisting castings is very interesting and while some products are fully developed, the industry is just getting started and interesting developments in the future may be looked for.

The company expects to carry on considerable research work in the development of new castings.

Uranium in High-Speed Steel

The most recent development in high-speed steel is the remarkable effect of the alloy uranium on this class of material. This is shown by the results of tests of uranium high-speed steel in comparison with regular high-speed steel at present in use, given in Table I.

TABLE I

Tool	Feed, In.	Speed, F.p.m.	Cut, In.	Remarks
U-a	3/32	103	3/8	Ran 5 in.
A	3/32	103	3/8	Ran 2 1/2 in.
Material cut: loco axle				
U-a	1/16	74	5/8	Ran 12 in.
A	1/16	74	5/8	Ran 2 in.
U-a	1/16	94	5/8	Ran 5 in.
A	1/16	94	5/8	Ran 2 in.
Material cut: loco crankpin				
U-1	1/16	75	1/4	Went over once distance of 14 in. (in second lap went 3 in.)
B	1/16	75	1/4	Went distance of 4 in.
D	1/16	75	1/4	Went distance of 1 in.
Material cut: 50 per cent carbon 12 in. shaft				
U-1	1/16	51	5/8	Went over twice. Cut changed to 3/8 in. on second turn.
C	1/16	35	5/8	Did not go 1 in.
Material cut: 8 in. shaft 7 ft. 5 in. long				
U-1	1/32	75	5/8	Ran 18 in.
U-2	1/32	75	5/8	Ran 13 in. Speed increased to 90 f.p.m. and ran 11 in. Tool still good.
B	1/32	75	5/8	Ran 11 in.
Material cut: 6 in. shaft				
U-4	1/16	60 to 65	5/8	Went 8 in.
U-2	1/16	65	5/8	Went 4 in. Speed increased to 80 f.p.m. and went 3 1/2 in.
Material cut: 10 in. shaft				
U-1	3/64	55	5/16	Went 16 in.
U-5	3/64	55	5/16	Went 15 in.
B	3/64	55	5/16	Went 2 1/2 in.
Material cut: 12 in. shaft 22 ft. long				
U-5	1/16	45	5/8 to 3/4	Ran 57 in. Most of time the nose of tool was right on scale.
U-5	1/16 to 1/10	38	15/16	Went 127 in. Time 3 hrs. Speed increased to 65 f.p.m. after 105 in.
U-5	1/16	60	1 1/16	Ran 12 in.
Material cut: 12 in. forging				

The tools marked A, B, C and D are regular high-speed steel tools. Those marked U are uranium high-speed steel tools.

The manufacture of uranium high-speed steel is being taken up by a number of concerns. The tests of Table I were made under the direction of the Standard Chemical Company on a commercial scale at a number of the important shops in the Pittsburgh district.

Second National Exposition of Chemical Industries

The managers of the Second National Exposition of Chemical Industries which will be held at the Grand Central Palace, New York, during week of September 25-30, 1916, report that all space on the main floor has now been engaged, and that they have had to arrange for the second floor on which a great deal of space is already taken by exhibitors.

It is on this floor that the Government is expected to exhibit. Here also the "Made-in-America" meetings of the American Electrochemical Society will be held in the conference auditorium which the managers are erecting. The industrial conferences of the American Chemical Society, which will be presided over by its officers, in which heads of industries will participate, will also be held in this conference hall.

The American Paper and Pulp Association have their program in progress, and the managers report that they are organizing a section for the paper and pulp industry, which will cover considerable space on the second floor showing paper-making machinery, materials, products and by-products.

All motion pictures, covering every phase of industry, will be shown on this floor during the Exposition.

Several other societies have signified their intention

of supporting and exhibiting at the Exposition but have not as yet made known their programs.

With all these things, it is an assured fact that this exposition will transcend all the bounds of success of the former held last September.

Personal

Mr. Glenn L. Allen is now metallurgist for the Shattuck-Arizona Copper Company, Bisbee, Ariz.

Mr. M. H. Atwater is in charge of the erection of the electrolytic zinc plant for the Judge Mining & Smelting Company at Park City, Utah.

Messrs. C. C. Brayton and E. R. Richards have opened offices in the Hobart Building, San Francisco, as mining and metallurgical engineers.

Mr. H. Kenyon Burch, chief engineer for the Inspiration Copper Company, is taking a vacation in the East, following the completion of work on the design and construction of the company's concentrating plant in Arizona.

Mr. George A. Guess, professor of metallurgy in the University of Toronto, has been retained to start the copper smelter of the Vermont Copper Company at South Strafford, Vt.

Dr. Henry M. Howe, emeritus professor of metallurgy in Columbia University, has been appointed honorary vice-president of the Iron and Steel Institute of Great Britain.

Mr. E. C. Irwin has been appointed Cincinnati, Ohio, representative of the Asbestos Protected Metal Company, Pittsburgh.

Mr. Robert M. Keeney has resigned his position with the Snyder Electric Furnace Co. and is at his home in Chicago.

Mr. R. L. Lee has been appointed superintendent of the smelter of the Central Chili Copper Company at Panulcillo, Chile.

Mr. J. H. O'Brien of the American Blower Company, has been transferred from the Detroit office to the Chicago office, where he will give special attention to the air conditioning field in that territory.

Mr. H. A. Plusch, for the past seven years chief ceramic chemist for the Atlantic Terra Cotta Company, has resigned to take up the general field of consulting engineer in firebrick, refractory slab, terra cotta, faience, saggar, stoneware, sanitary ware, development of clay lands and new clay products. His offices will be at Perth Amboy, N. J.

Mr. W. H. Staver, formerly manager for the Liberty Bell Gold Mining Company, Telluride, Col., is investigating manganese deposits in the Southeast, and has opened an office in the Krise Building, Lynchburg, Va.

Messrs. Maurice W. Summerhayes and C. H. Poirier, respectively managers for the Porcupine Crown and Porcupine Vipond companies, have been selected to value the McIntyre, McIntyre Extension and Jupiter properties to determine the basis of a merger.

Dr. F. W. Traphagen, Golden, Col., has accepted the presidency of the Colorado Metal Mining & Reduction Company, and will devote his time to the company's metallurgical interests.

Mr. Charles E. van Barneveld is in New York on professional business and may be addressed care of the American Institute of Mining Engineers.

Mr. William H. Warren has been appointed manager of the works of the Brier Hill Steel Company at Youngstown, Ohio.

Mr. George J. Young, professor of metallurgy in the Colorado School of Mines, recently visited metallurgical plants in Nevada and California. He is spending the month of July on an outing in California.

Obituary

Sir William Ramsay, the eminent English chemist, died at his home, Beechcroft, at Haglemere, Bucks, in his sixty-fifth year, on July 23. He was born in Glasgow and educated in Glasgow Academy and University. He then took up teaching work and was subsequently associated with a number of universities, the last one being the University College of London, from which he retired as professor emeritus of chemistry in 1913. He was perhaps best known for his work on the gases of the atmospheric, including the discovery of argon in collaboration with Lord Rayleigh. He was the author of many valuable contributions to chemical literature, chiefly on the gases of the atmosphere, production of helium from radium, and general physical chemistry. He visited this country several times and was Lovering lecturer at John Hopkins University. He also delivered a number of lectures at other institutions. He was the recipient of the Nobel prize in 1904 and received a number of other prizes for his work. He was president of the Seventh International Congress of Applied Chemistry in London in 1909; was a past president of the Society of Chemical Industry and Chemical Society, and was a member of a large number of scientific societies.

Charles W. H. Kirchhoff, editor of the *Iron Age* from 1889 until 1910, and a past president of the American Institute of Mining Engineers, died at his summer home, at Asbury Park, on July 23, in his sixty-fourth year. He was born in San Francisco, Cal., and was graduated from the Royal School of Mines in Clausthal, Germany, in 1874. He returned to this country and was chemist of the Delaware Lead Refinery, Philadelphia, Pa., for three years. He joined the *Iron Age* in 1878 and remained until 1881, when he became managing editor of the *Engineering and Mining Journal*, returning to the *Iron Age* in 1884. In January, 1910, he was tendered a luncheon at the Engineers Club in New York by a number of his friends, in recognition of their admiration for him as an editor and a man. This was on the occasion of his retirement as editor of the *Iron Age*, with which he had been associated for over 30 years. He was a member of the American Iron and Steel Institute, The Iron and Steel Institute of Great Britain, The American Society of Mechanical Engineers, The Verein Deutscher Eisenhüttenleute and an honorary member of The Franklin Institute of Philadelphia.

Samuel Waterhouse, Jr., organic chemist, for some time past superintendent of the Frank L. May Chemical Company of Perth Amboy, N. J., died in the City Hospital of that city of aniline poisoning on July 8.

Industrial Notes

Nickel Refining—Premier Hearst, chairman of the Provincial Government Nickel Commission of Canada, is experimenting with an electrolytic nickel refining process, and considerable money will be spent on equipment.

The plant of the Virginia-Carolina Chemical Co., at Americus, Ga., was struck by lightning on July 10, and was subsequently destroyed by fire. The plant is said to be insured.

New Porcelain Ware Made in United States—The Guernsey Earthenware Co., Cambridge, Ohio, have issued Catalog No. 5 describing its new product, "Guernsyware," chemical laboratory porcelain. Tests made on

this porcelain have shown it to be the equal of the imported ware, and satisfaction is expressed by those who have used the products.

The German American Car Company announces a change in name to the General American Tank Car Corporation, and will continue its business under the same management and in the same manner as in the past, but with largely increased facilities.

The Block Chemical Laboratories of Chicago were incorporated under the laws of Illinois on June 16. The officers are: Dr. D. Julian Block, president; Prof. Robert M. Cole, vice-president, and Howel B. Keeler, secretary.

The Kansas Chemical Mfg. Co., at Hutchinson, Kan., is constructing a new \$30,000 hydrating plant and a \$20,000 lime plant of four kilns at Moline, Kan., where limestone quarries are located. The new plant will be ready for operation in about two months.

The Providence Engineering Society will occupy its new rooms at 29 Waterman Street, Providence, R. I., when it opens up for its fall and winter work next September. The whole second floor of the building has been taken over and will be remodeled and equipped in a modern and attractive manner. The society expects to pursue a very interesting and useful line of work for the coming year.

The Commercial Attache of the American Embassy at Paris, France, Mr. C. W. A. Veditz, is desirous of receiving catalogs, price lists and similar printed material from American concerns interested in the French and Spanish markets. The commercial office is in receipt of numerous inquiries for the names and addresses of American firms producing a variety of products and desires to have the catalogs on hand to show to inquirers.

The Hoskins Manufacturing Company, Detroit, Mich., announces a change in the address of its Boston office from 613 Unity Building, to 445 Tremont Building, 73 Tremont Street. The office will continue to be in charge of Mr. J. E. Hines.

Pulverized Coal in Open-Hearth Furnaces.—The Raymond Bros. Impact Pulverizer Co., Chicago, Ill., has recently received an order from the Carnegie Steel Co. for seventeen of its largest sized mills for pulverizing coal for use in open-hearth furnaces. Other orders have recently been received for experimental and complete installations.

New Building for Manufacture of Rubber Gloves—The Lee Tire & Rubber Co. has just placed with John W. Ferguson Co. of New York, and Paterson, N. J., a contract for the erection of another building at its Conshohocken plant. To this building will be transferred that portion of the company's business which has to do with the manufacture of rubber gloves and similar rubber products. The building measures 80 ft. by 120 ft. in plan, and will for the present contain but two stories. The foundation and reinforced concrete columns on the first floor are designed, however, for several additional stories with the idea of probable expansion in view. A wooden roof will be placed over the second story. The walls of the building will be brick and the floors reinforced concrete. Steel sash will be used in the windows. H. M. Haven & Wm. W. Crosby of Boston drew up the plans and specifications.

The International Oxygen Company, with offices at 115 Broadway, New York, is installing a new plant at College Point, L. I., for the manufacture of oxygen and hydrogen gas. It is expected that the installation will be completed late in August or early in September after which the company's increasing trade in Brooklyn

and environs, as well as in Manhattan, will be largely handled from this point. Heretofore this local business has been supplied from the company's Newark works, and the new location will mean larger and better facilities and more prompt service in the supply of gases in cylinders. The manufacture of gas-generating apparatus is the main business of the company, this feature of its work being concentrated at the Newark factory. The manufacture and distribution of gas in cylinders is a local and a secondary feature. The Newark and College Point plants supply Greater New York and the adjoining industrial section of New Jersey. The plant at Verona, Pa., has its outlet in the Pittsburgh district.

Digest of Electrochemical U. S. Patents

PRIOR TO 1903

Arranged according to subject-matter and in chronological order.

Compiled by Byrnes, Townsend & Brickenstein, Patent Lawyers, National Union Building, Washington, D. C.

Aqueous Bath, Cathodes Metalizing

29,144, July 17, 1860, Joseph Corduan of Brooklyn, N. Y.

Relates to electroplating the face of type with brass. To a saturated solution of blue vitriol add a caustic potash solution until no further precipitate forms. The precipitate is "black oxid of copper." It is washed well, and dried. The dried oxid is added to a cold solution of potassium cyanid until no more dissolves. To a similar solution of potassium cyanid, heated to boiling, is added oxid of zinc until no more dissolves. Equal volumes of the clear solutions are mixed and used as the electrolyte, while for a hard brass, an excess of the zinc solution is used; and for a soft brass, an excess of the copper solution is used. Brass vats are preferred to hold the electrolyte, and the vat may serve as anode, or a separate anode may be inserted in the solution. The type are assembled and held in a brass clamp, the faces being perfectly level, and the faces only immersed in the electrolyte.

63,512, April 2, 1867, Samuel Hallock of New York, N. Y.

Relates to an apparatus used in electrotyping, and consists of a frame to support the wax mold, and an auxiliary frame carrying a plurality of light spring contacts to make electric contact with the graphite on the face of the impressed mold. All submerged metal parts are protected by a coating of wax or rubber, except the contacting surfaces of the springs.

83,747, Nov. 3, 1868, Dennis C. Wilcox of Meriden, assignor to Meriden Britannia Company, of West Meriden, Conn.

Relates to the manufacture of double-walled ice pitchers, and similar vessels, and consists in electroplating the unprotected surfaces of the enameled or glazed metal at the edges where they are to be joined, and then soldering the joint at the electroplated parts.

90,892, June 1, 1869, Hiram Tucker of Newton, Mass.

Relates to surfacing articles of cast metal which have raised and depressed portions. The depressed portions are filled with wax or other filling, and the raised portions, after suitably grinding and polishing, are electroplated with any desired metal. Or the raised surfaces may be electroplated first, and the depressed portions filled in with wax or the like, later.

94,453, Aug. 31, 1869, William T. Tibbals and Lyman B. Tibbals of Cohat, Conn.

Relates to electroplating the joined and riveted edges

of such articles as cow-bells, the electroplated joint constituting an electro-soldered joint, and is effected at the same time that the bell is electroplated.

102,077, April 19, 1870, Joseph A. Adams of Brooklyn, N. Y.

Relates to electrotyping, and consists of a holder constructed to receive the black-leaded type-mold and frame, and make contact with the frame only. The holder consists of a hinged clamp, which may be screwed tight against the frame, and is provided with two points or lugs which engage corresponding holes or recesses in the frame. At the lower end of the clamp extending behind the frame is an adjustable clamp to hold the lower portion of the frame.

114,447, May 2, 1871, Silas P. Knight of Brooklyn, N. Y.

Relates to coating an electrotype mold with graphite, the graphite being first moistened with alcohol, and then mixed in the proportion of 1 lb. of graphite with 1 gal. of water. The mold filled with wax is first coated with water and graphite, the impression of the type made, then the mixture of water and graphite applied in fine streams from a "rose," and the excess of graphite finally washed and brushed off. Instead of graphite, bronze or similar powder may be used.

168,442, Oct. 5, 1875, William E. Worthen and Richard S. Gillespie of New York, N. Y.

Relates to electroplating such metallic objects made of iron and zinc with copper. The object is first coated with a mixture of red mercury oxid, alone or mixed with some mercury sulfid, and a waterproof vehicle, such as oil, to form an oxid of mercury paint, and this coating is then covered with a film of graphite. The article is then immersed in a solution of copper sulfate, and electrodeposited as usual. It is thought the mercury oxid and sulfid are reduced to metallic mercury, thereby forming a good connection through the paint to the metal beneath. If desired, copper rivets or wires may be secured in the metal object, extending through the paint and graphite coatings, and be united to the electrodeposit. Instead of depositing upon a metal object, the deposit may be made upon an article made from a mixture of ground coke and asphalt, thoroughly mixed while hot and molded into the desired shape. Such articles are first coated with graphite in the recessed parts, and electroplated, then the remainder coated with graphite, and electroplated. With large objects, such as a fountain, it is put into a tank and the electrolyte gradually increased in depth until it is entirely immersed, the anodes being raised with the electrolyte.

199,366, Jan. 22, 1878, Gustave Hubmann of New York, N. Y., assignor to Felix Marx of same place.

Relates to ornamenting marble and the like by electrodeposition. The marble is first cleaned, then coated with a light-sensitive emulsion of bichromate of potash and gelatine, then a suitable design made of varnished paper is secured to the emulsion, and the marble exposed to the light to render the exposed emulsion insoluble in water. The design is then removed, and the coating is then treated with alcohol to harden the emulsion not exposed to light. The marble is then placed in hot water to remove the non-exposed emulsion, after which the marble is washed and treated with acid to etch the uncovered portions. It is then washed with water and treated with benzine to remove the remaining coating, then the etched parts are varnished and coated with graphite, pieces of wire or rivets also being secured to the marble to anchor the deposit, and then immersed in an electrolyte to be copper-plated, after which the marble and deposit are polished and the metal engraved if desired.

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Who Produces the Metals?

The national advantage of holding premier rank among the world's metal-producing countries has been accentuated by the war. To both belligerent and neutral nations the control of the output of any metal has become an important asset, either through supplying domestic needs or by increasing revenue through sales to neighbors less fortunately situated. The international scramble for metals has directed attention most forcibly to the sources of the world's metal supply and has brought into prominence some of those that hitherto have been obscure or relatively unimportant.

Among precious metals, 60 per cent of the world's production of gold is controlled by Great Britain, mainly in South Africa and Australasia. This, together with the further fact that less than 1 per cent of the world's gold comes from European countries, has undoubtedly had a great economic effect in the conduct of the world's business during the war. The United States holds second rank in the production of gold, but first in the case of silver, producing about 30 per cent of the world's total. Under normal conditions Mexico would be a close second, with Canada, Australasia and Germany following. Russia is unquestionably the leader in platinum, as no new source has appeared comparable with the placers of the Urals. Colombia is next in importance to Russia, but, besides these two countries, the others, including our own, make but nominal output.

In pig-iron and steel the United States easily holds first rank, with an average production in recent years of about 40 per cent of the total. Germany follows with about 25 per cent. The United Kingdom is third, and France and Russia divide fourth place.

The pre-eminence of the United States also becomes apparent when considering the common base metals—copper, lead and zinc. Of late years we have produced about 55 per cent of the world's output of copper. In 1913 the next nearest competitor, Japan, turned out only 7 per cent of the whole, which clearly demonstrates our own position. Chile, Australasia, Spain, Mexico, Germany and Canada follow with minor percentages. With regard to lead our position is not so strong, though we still lead other countries with a production of about one-third the total. Spain takes second place, with about one-fifth, with Germany and Australasia following. Mexico has held a stronger position than she now occupies, having produced more than one-tenth of the world's output during the period 1903-1911. In spelter production we were credited in the years 1909-1913 with slightly over 30 per cent of the whole. It is greater at the present time, due not only to increased production at home, but also to enforced curtailment abroad. Germany, which for years has distilled the

major portion of zinc concentrates from Australia, has been a very close second during this period, but has not quite equalled our output. Belgium was third with about 20 per cent, and the three countries together accounted for over 80 per cent of the world's spelter. France, Spain and Great Britain have been in minor positions.

Among the minor metals our position is not so prominent. In quicksilver production, Spain, Italy and Austria all surpass us in the order named, Spain producing more than twice as much as the United States. Since 1908 China has led in antimony, producing from two to three times as much as France, which holds second place. Practically all the antimony metal used in the United States is imported from European smelters, our own production being confined to that contained in antimonial lead. Our position is more favorable with regard to aluminium. Estimates of the world's output for 1914 credit the United States with almost half the total; France about one-seventh; Switzerland about one-eighth. Great Britain, Canada, Norway, Austria-Hungary and Italy provide the balance. In the case of nickel we again lead, through our refining of Canadian mattes, but not from treating domestic ores. New Caledonia is the only important competitor of the Sudbury district, Canada, in the production of nickel.

When it comes to the less common metals like molybdenum and tungsten, we realize the world's dependence on relatively obscure sources, though greater domestic production might be stimulated by unusual conditions. No commercial production of molybdenum was reported in the United States in 1914, and the world's principal supply came from Australia. Norway also was an important producer and Canada had made some production. During the past year both domestic and Canadian production has been stimulated. In tungsten we hold a more important place, being second to Burma, which took the lead in 1912. For the period 1912-1914 we produced about 14 per cent of the tungsten of the world, while Burma is credited with 18 per cent.

On the whole, the position of the United States is seen to be an important one. Of the thirteen metals considered, we hold first rank in the production of seven and second in the case of two. In the balance our output is of minor importance, if not negligible.

Congress and Technical Affairs

Consider the Congressman, how he votes. Occasionally it seems almost as though he knew not, neither did he think. And yet the engineer with all his knowledge is not clothed with the political power of one of these. All of which points a double moral: the necessity of the education of our law-makers in technical matters, which can be accomplished only through greater activity of engineers in the realm of public affairs. Too long has the engineering profession held aloof from those who make our laws and run our government, forgetting that much of the business of state is concerned with problems in organization, management and economics, for which successful engineers should be well fitted.

The fault, when such exists, lies not altogether with public servants, many of whom would lend a willing ear to sound advice on technical matters. Never was a time so propitious for such advice as the present, when public officials are called upon to legislate on matters affecting our industrial growth and welfare, the technique of which is best appreciated by scientists and engineers.

In our last issue, for example, we called attention to the intricacies of the several proposals for a protective dyestuff tariff, and showed that while progress has been made toward an intelligent consideration of this most important matter, it may yet fail of the full measure of attention it demands. And who so well qualified to point the way, avoid the pitfalls and prevent the passage of an abortive half-measure as those who know the technical phases of the industry?

Recently the subject of scientific management received consideration at the hands of Congress in such a manner as to elicit caustic criticism and ridicule from layman as well as engineer. The House passed a bill forbidding time and motion studies on government employees, and prohibiting the adoption of any scheme of remuneration involving bonuses or premiums for excellent work. This is a sad and disgusting spectacle, considering the truly remarkable achievements of scientific management and organization in various industrial lines. It is typical of the manner in which Congress plays politics with matters that should receive intelligent and broad-minded treatment. Instead of welcoming the possibility of placing the Government's business on a basis of efficiency, Congress yields to political pressure, throws a sop to a prejudiced faction, and holds departmental work to the dead level of mediocrity. At a time when private business is being forced to study efficiency and the whole country realizes the necessity of such action, and when one of the candidates for President is talking about "America Efficient," Congress exposes its own inefficiency by putting a spoke in the wheel of progress. Popular impression prevails that governmental departments are not on an efficient basis, and engineers can render a service to the country by expressing that opinion in a manner so forceful as to show Congress the light.

In matters more vital to the mining and metallurgical industries Congress acts with even less discretion. The recent proposed tax on copper for the purpose of raising revenue is a case in point, showing how illogically and superficially a profound subject may be approached. Apparently sensing a popular impression that copper is a highly profitable constituent of war munitions, and without first establishing a broad, fundamental, economic basis for raising revenue in an equitable manner, Congress singles out copper for taxation and gives itself over to class legislation of the wildest sort. If the storm of protest that has been aroused does not call the national legislature to its senses, it is indeed immune to criticism. Such unfair taxation as is proposed in the case of copper can be charged only to astounding ignorance of conditions. Admitting that taxation for revenue is a tremendous prob-

lem, there is the greater need to stop, look and listen before proceeding blindly.

We presume that instances might be multiplied to prove political inadequacy in dealing with technical affairs. Congressional proposals for the revision of the mining law, and political interference with the work of our technical bureaus furnish other examples. We need more representatives of science and industry in Congress, and fewer politicians and lawyers. Then, perhaps, the Government will conduct its business in a more efficient manner and without regard to political expediency. In the meantime, with all its unwise proposals in technical matters, Congress continues to caress the pork barrel with wonted satisfaction, unwilling to play its part in economy and efficiency. The situation calls for intelligent help, which it becomes the duty of engineers to offer.

The Bureau of Mines' New Stations

By an act of Congress passed over a year ago the Bureau of Mines was authorized to establish ten experiment stations for mining and metallurgy, in addition to the five already existing at Pittsburgh, Denver, Salt Lake City, San Francisco, and Urbana, Ill. It was provided that not more than three of the new stations should be established in any one year, and it was expected that their work would be supplemented by appropriations from the States in which they should be located. The first three of these stations are to be established this year, and the sum of \$25,000 is appropriated annually for each of them.

Two of the new stations have been definitely located at Fairbanks, Alaska, and Tucson, Arizona. The third will be placed somewhere in the Northwest, in Washington, Idaho or Montana, and Director Manning is now on a trip of inspection to decide the location. We understand that the selection will be made wholly with a view to the best service that can be rendered to the industry by the Bureau, and that political pressure or flattering offers of local assistance and cooperation will receive minor consideration. The station may go to Butte, Seattle, Moscow or Pullman, each of which is reported to be bidding actively for the director's favorable consideration.

The Arizona station will be at Tucson where the State school of mines is situated, and co-operative work will be carried on by the two organizations. Similar arrangements now exist at Salt Lake City, Urbana and Golden, where the Universities of Utah and Illinois and the Colorado School of Mines, respectively, have co-operative agreements. The station at Golden was recently removed there from Denver and is now occupying an entire building placed at its disposal by the Colorado School of Mines.

When it was first proposed to establish ten new stations, each with an annual appropriation of \$25,000, we opposed the plan because we believed a single station centrally located, with \$250,000 per annum at its disposal could do more effective work. It seemed, furthermore, that ten stations must inevitably duplicate equipment and staff to an alarming degree. Apparently it

was impossible to put such an economic measure through Congress, and Dr. Holmes, who was then director of the Bureau, made the best of the situation and accepted the ten stations as an alternative.

This plan is now going into effect and a definite line of work is being assigned to each station so that duplication of work, at least, is being avoided. Thus the Urbana station appropriately confines its work mainly to coal; Tucson will study problems relating to copper; Golden is devoted to investigations of the rare metals, and so on. The location of stations at State schools is a policy that should be fruitful of results for both parties to the arrangement. If the States make appropriations commensurate with the sums expended by the Bureau, double the amount of work can be accomplished at half the cost to either party. As a rule the schools are able to offer housing, equipment, laboratory and library facilities that save the Bureau a large sum of money and leave its funds available for research work.

In a measure the whole scheme of separate stations may be considered experimental, and the future policy of the Bureau probably will be determined by the success or failure of the plan. If, after a few years' trial, it is found inexpedient, the separate stations may be combined at a central point. In the meantime the whole industry, and particularly the States concerned, should make a consistent effort to support the Bureau in getting the best possible results.

Tungsten

According to statistics gathered by the U. S. Geological Survey, the tungsten production of the United States during the first six months of 1916 exceeded the production of this or any other country in any previous twelve months. The output was equivalent to about 3290 short tons of 60 per cent WO_3 concentrates, and was valued at \$9,113,000. If the tonnage was remarkable, the value was even more so. The last six months of the year probably will show a decrease in production and assuredly a marked reduction in value, for it seems certain that so spectacular a market for tungsten will not be experienced in many years, if ever.

Colorado has regained first place as a tungsten producer and Boulder is again the premier district. California is second, with Nevada and Arizona following. Nearly all of the western States reported some production. But if reports regarding a new tungsten discovery in Nevada are confirmed, Colorado and other States may be relegated to minor positions. A deposit remarkable both for its extent and grade of ore is now being developed and a concentrating mill is under construction. In addition to ore of milling grade, large quantities of shipping ore are reported.

The situation in Colorado has become more stable, and operators are wisely turning their attention to the production of such finished products as ferrotungsten, tungstic acid and metal, instead of marketing raw concentrates. Tungstic acid has been produced for some time by at least two concerns, and improved methods of treatment are reported as a result of the research that has been under way for the past year.

Readers' Views and Comments

The Distribution of Silver Between Metallic Lead and Litharge—Containing Slags

To the Editor of Metallurgical & Chemical Engineering

SIR:—I have been much interested in the article by Prof. Boyd Dudley on "The Distribution of Silver Between Metallic Lead and Litharge-Containing Slags," which appeared in the issues of June 1 and 15. His research shows clearly among other things: (a) the advantage of using as little litharge-containing slag as consistent with good fusions; (b) the reason why a long, slow fusion of excess litharge slag, ending at a moderate temperature, gives a better silver result than a quick, hot fusion; (c) that the reduction of a small lead button in the crucible, resulting in a high silver concentration, will be accompanied by a high slag loss, which may, however, be partly balanced by a lower cupellation loss. These facts have in the past been more generally accepted than understood.

The question whether silver in assay slags is dissolved or oxidized is interesting, but difficult of proof one way or the other. The slags obtained in commercial copper matte smelting, to which Professor Dudley has referred, probably hold a part of their silver as oxide (*E. & M. J.*, Vol. 100, pages 215, 263, 305). If excess litharge flux be used for silver determinations, fairly good results may be obtained by performing the fusion in a strongly reducing atmosphere, which may be easily obtained by filling several crucibles with soft coal and placing them in the muffle with the fusions. This should not affect the solubility of silver in litharge, but might reduce silver oxide to some extent. Oxidation of silver is also suggested by the lower slag loss of gold, which is not readily oxidized. Probably oxidation and reduction both take place; if so, Professor Dudley's work shows that they obey similar laws.

Yours truly,

FRANK E. LATHE.

The Granby Consolidated Mining, Smelting & Power Co., Ltd.,
Grand Forks, British Columbia.

Rapid Analysis of White Bearing Metals for Copper and Lead

To the Editor of Metallurgical & Chemical Engineering

SIR:—The following method for the rapid analysis of white bearing metals for copper and lead has been used by me many times and I have found it very rapid and at least as accurate as any of the other technical methods for the determination of these two elements.

Take 1.0 g. sample in a 150 c.c. beaker, add a pinch of tartaric acid and 20 c.c. aqua regia, and heat to solution. Remove from the hot plate, rinse into 50 c.c. 25 per cent NaOH contained in a 400 c.c. beaker, add 15 c.c. 25 per cent Na₂S and heat just to boiling over the flame, keeping the beaker in constant motion. Remove from the flame, allow to settle a moment, and filter through an 11 c.m. hard paper (with suction). Wash four times with dilute hot Na₂S solution. Transfer the paper and ppt. to a 250 c.c. beaker, add 10 c.c. conc. HNO₃, boil until the paper is disintegrated. This should be carried on over a good flame. Now add 5 c.c. conc. H₂SO₄ and boil until the solution has turned black. Add 3 c.c. conc. HNO₃, and again boil until the solution turns dark. Repeat alternate additions of HNO₃ and boiling until the solution goes down to SO₂ fumes without any appreciable darkening. Remove from the flame, cool with the air

jet, dilute with cold aq. to 50 c.c. and if the percentage of lead is below ten, add an equal volume of grain alcohol. Stir well, allow to settle a moment and filter through an 11 cm. double paper. Determine the Cu either electrolytically or by iodometry. Determine the lead as sulphate, or by one of the standard volumetric methods. An analysis may be completed in one to one and a quarter hours.

Hoping this may be of service to your readers as it has been to me, I beg to remain,

W. L. JACKSON.

E. C. Atkins & Co.,
Indianapolis, Ind.

Western Water-powers and Electrochemical Industries

To the Editor of Metallurgical & Chemical Engineering

SIR:—Your comment in the issue of July 1, upon the article on the electrochemical possibilities of the Pacific Coast, by Mr. Beckman, in the same issue, furnishes incentive for discussion in the statement that "It would be plain foolishness to think that the abundant and cheap water-powers of the Pacific Coast could be made to supply the principal markets now supplied by the electrochemical industries of Niagara Falls . . . the manufacturing districts of the East and Middle West."

On second thought, is this statement entirely consistent with the statements of the advocates of Niagara Falls as against the rest of the country, that "large industries are being driven to Europe and to Canada on account of the famine of power which exists at Niagara Falls?"

Is it not a fact that the prices of electrochemical products and metals are based on seaboard deliveries, generally?

It will hardly be contended that there is any less tendency now than heretofore for the broad chemical and metal industries to seek the seaboard, around the world. It would, therefore, appear to be still true that the Atlantic, Gulf and Pacific seaboard are quite as important market and transportation factors as the Great Lakes.

Specifically, we would cite the case of aluminium, the most important electrochemical industry, and the one consuming the most power. It is hardly fair to contend that Niagara Falls and Canada is the natural and only feasible region for the economical production of aluminium; the ore going from Arkansas to East St. Louis for concentration, thence to Niagara Falls and Canada for reduction, and the metal again returning to St. Louis and to New York—the centers of population and manufactures of the Middle West and of the East, to which you refer—and wherein the ores and other considerable materials consumed in the production of aluminium, and the metal to market, are carried almost entirely by rail, at three to ten times the cost of water transportation.

The Great Lakes are certainly not a controlling factor in this electrochemical industry.

Wherein would really cheap water-power, and aluminium ores and carbonate of soda, and electrode carbon, within a few miles of seaports with cheap fuel, on the Pacific, be handicapped in comparison with Arkansas and Niagara Falls and Canada?

F. LANGFORD.

Eureka, California.

Metallurgical Plants of Arizona

A Brief Summary of the Extent of Metallurgical Practice in Arizona, and the Itinerary of the Tour of the American Institute of Mining Engineers

THE meeting of the American Institute of Mining Engineers in Arizona, Sept. 18 to 24 inclusive, directs attention to the important place which that State now occupies in mining and metallurgy. It holds first place in production of copper, having excelled Montana in that respect. It contains also within its borders, though not on the Institute route, the newest and most important gold-mining district, Oatman, where new metallurgical plants are in course of erection. In fact, general progress in mining, smelting, concentrating and cyaniding in Arizona has been so rapid and interesting that it holds unusual attraction for engineers who are fortunate enough to find time for even a brief visit to the principal districts. Technical skill is represented in the highest degree among the engineers who are in charge of operations, and they are not lacking in those qualities of friendliness and generosity toward the profession that make for progress through a courteous exchange of information. These features, combined with the fact that the Institute's president, Dr. L. D. Ricketts, has been a leading factor in the development of mining and metallurgy in Arizona, make the prospective meeting most opportune.

A special train will be at the disposal of the Institute party, leaving New York Thursday, Sept. 14, and arriving at El Paso, Tex., Sunday, Sept. 17. From El Paso the itinerary includes continuous visits for a week to the principal mining and metallurgical districts of Arizona, with a short stop in New Mexico, ending at the Grand Canyon on Sunday, Sept. 24. A brief outline of the tour follows; full details can be secured from Institute headquarters.

Monday, Sept. 18.—Mines of the Chino Copper Company and mill of Empire Zinc Company, Santa Rita, N. M. Mill of the Chino Copper Company, Hurley, N. M.

Tuesday, Sept. 19.—Reduction works of Copper Queen Consolidated Mining Company and of Calumet & Arizona Mining Company, Douglas, Ariz. Technical sessions on smelting and leaching.

Wednesday, Sept. 20.—Mines of the Bisbee district. Technical session on mining and geology.

Thursday, Sept. 21.—Mines and reduction works of Old Dominion Copper Company, Globe. Technical sessions on concentration, flotation and fine grinding.

Friday, Sept. 22.—Reduction works of International Smelting Company and mills of Inspiration Consolidated Copper Company and Miami Copper Company, Miami. Technical session on mining and smelting.

Side trips can be arranged from Globe to mines of the Ray Consolidated Copper Company at Ray, or over Apache trail to Roosevelt dam. The main party will travel via Phoenix to the Grand Canyon, where Sunday will be spent, after which the special train will return to New York.

The visits to mines and metallurgical plants, and the technical sessions will be interspersed with social functions, which will add pleasure and profit to the trip.

Summary of Metallurgical Plants

That those who plan to attend the meetings may have an idea of the extent of metallurgical practice in Arizona and a bird's-eye view of the processes and equipment that may be seen, not only on the Institute route but elsewhere in the State, we have prepared the accompanying map and data. The latter have been supplied mainly by officials of the different companies, or compiled from sources considered reliable. The order of their presentation is with reference to, first, the Institute main itinerary and scheduled side trips, and, second, other metallurgical centers in the State. Numerals and letters refer to locations on the map, the former indicating the Institute route and the latter other metallurgical centers.

Copper concentrating mills:
B Arizona Copper Company, Clifton.
F Consolidated Arizona Smelting Company, Humboldt.

B Detroit Copper Mining Company, Morenci.
3 Inspiration Consolidated Copper Company, Miami.
D Magma Copper Company, Superior.
3 Miami Copper Company, Miami.
3 Old Dominion Copper Mining & Smelting Company, Globe.

X Ray Consolidated Copper Company, Hayden.

B Shannon Copper Company, Clifton.

Copper reduction works:

C American Smelting & Refining Company, Hayden.
B Arizona Copper Company, Clifton.
1 Calumet & Arizona Mining Company, Douglas.
F Consolidated Arizona Smelting Company, Humboldt.

1 Copper Queen Consolidated Mining Company, Douglas.

B Detroit Copper Mining Company, Morenci.

3 International Smelting Company, Miami.

3 Old Dominion Copper Mining & Smelting Company, Globe.

B Shannon Copper Company, Clifton.

Z United Verde Copper Company, Clarksdale.

Cyanide mills:

A Commonwealth Mining & Milling Company, Pearce.

Z Copper Chief Mine (Hayden Development Company), Jerome.

G Gold Road Mines Company, Goldroad.

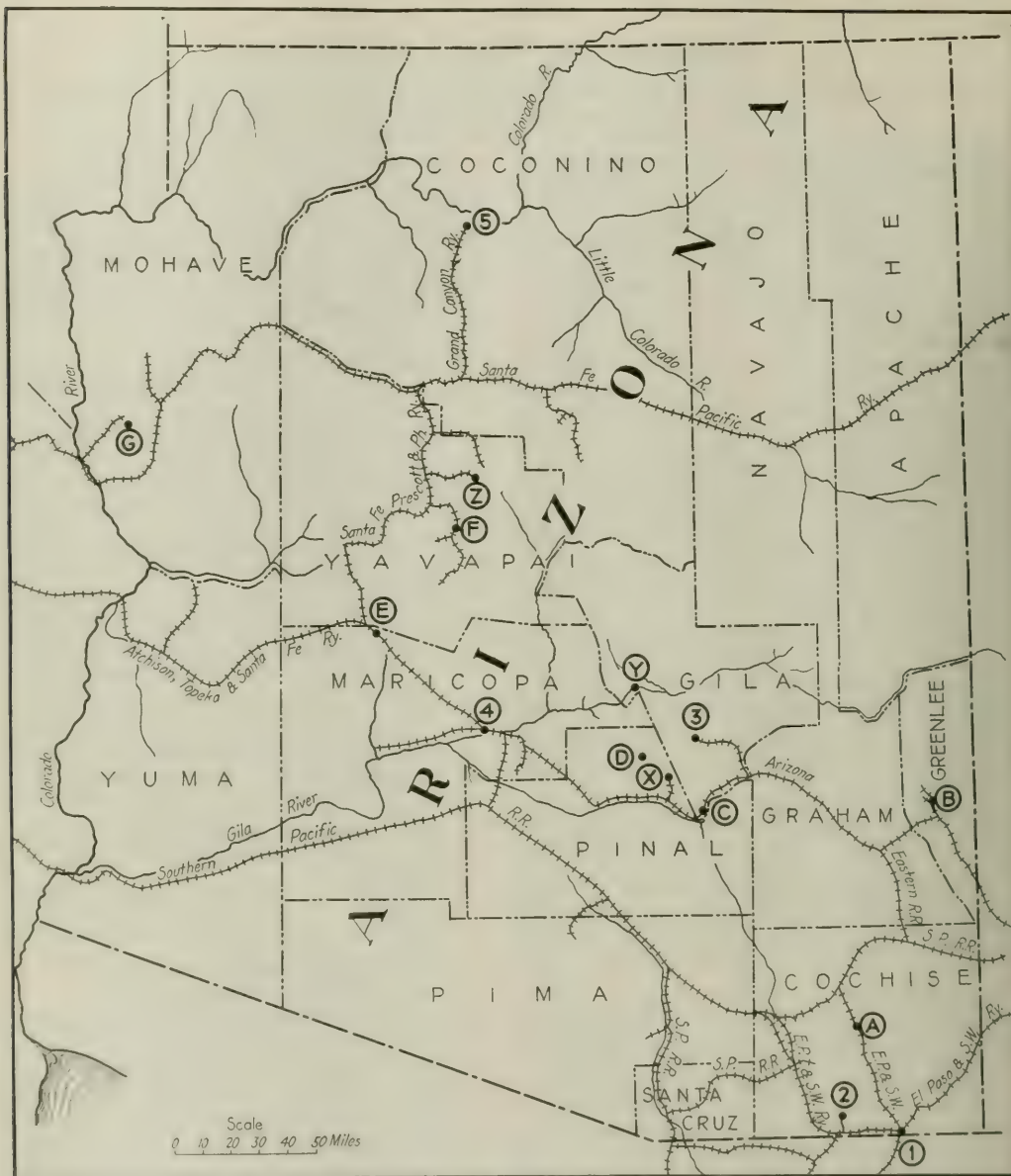
G Tom Reed Gold Mines Company, Oatman.

G United Eastern Mining Company, Oatman.

E Vulture Mines Company, Wickenburg.

On the Institute Route

1. Douglas. Calumet & Arizona Mining Co. smelting plant was completed in 1913, and contains two 48-in. by 40-ft. blast furnaces, four 19-ft. by 100-ft. reverberatory furnaces, twelve seven-hearth roasters 21-ft. 6-in. diameter, and six Great Falls type basic-lined converters. The plant is treating 3000 tons of charge per day and produces 7,000,000 lb. of copper per month. In addition to the smelting plant at Douglas, the company has under construction at Ajo a copper leaching plant which will have a capacity of 5000 tons per day. This plant is expected to be in operation early in 1917, and will be one of the most interesting examples of copper leaching in this country, producing 36,000,000 lb. of copper per year. Coarse crushing will be done with gyratories to about 3½ in., and with Symons disk crushers to ¼ in., at which size leaching will be done. Eleven lead-lined leaching vats will be 88 ft. square by 15 ft. deep, with an aggregate capacity of 5000 tons. Sulphur dioxide will be used for reduction of ferric iron



SKETCH MAP OF ARIZONA—LEGEND

The trip of the A. I. M. E. starts from El Paso, Texas, and the first stop is at Santa Rita and Hurley, N. M., to visit the mine and mill of the Chino Copper Co. From there the route lies through Arizona as shown below. Itinerary and points of metallurgical interest are indicated on the map by reference numbers and figures, as follows:

INTERESTS SHOWN IN ARIZONA

- 1 Douglas:
Calumet & Arizona Mining Co., Smelter.
Copper Queen Cons. Mining Co., Smelter.
- 2 Bisbee:
Copper Queen Cons. Mining Co., Mines.
- 3 Globe-Miami District:
International Smelting Co., Smelter.
Old Dominion Copper M. & S. Co., Smelter and concentrator.
Inspiration Cons. Copper Co., Concentrator.
Miami Copper Co., Concentrator.
- 4 Phoenix.
- 5 Grand Canyon.

SCHEDULED SIDE TRIPS

- X Ray:
Ray Cons. Copper Co., Mines.
- Y Roosevelt:
Reclamation project.
- Z Jerome-Clarkdale District:
United Verde Copper Co., Smelter.
Copper Chief Mine, Cyanide Mill.

OTHER METALLURGICAL CENTERS

- A Pearce:
Commonwealth M. & M. Co., Cyanide mill.
- B Clifton-Morenci-Metcalf District:
Arizona Copper Co., Smelter and concentrator.
Detroit Copper Mining Co., Smelter and concentrator.

Shannon Copper Co., Smelter and concentrator.

C Hayden:
American S. & R. Co., Smelter.
Ray Consolidated Copper Co., Concentrator.

D Superior:
Magma Copper Co., Concentrator.

E Wickenburg:
Vulture Mines Co., Cyanide mill.

F Humboldt:
Cons. Arizona Smelting Co., Smelter and concentrator.

G Goldroad-Oatman District:
Gold Road Mines Co., Cyanide mill.
Tom Reed Gold Mines Co., Cyanide mill.
New cyanide mills under construction at Oatman.

in the solution, and copper will be precipitated electrolytically.

The Copper Queen Consolidated Mining Company's smelting plant includes ten blast furnaces, sixteen six-hearth McDougal roasting furnaces, three oil-fired reverberatory furnaces and seven 13-ft. upright basic-lined converters. In 1915 the average tonnage smelted per blast-furnace day was 363.5; average product per roaster day, 47.5 tons of calcine; average daily reverberatory tonnage was 338.7, and copper bullion was made at the average rate of 32.6 tons per converter per day. Recent improvements made in overcoming dust losses at this plant are the subject of a paper to be presented at one of the Institute meetings.

2. Bisbee. Copper mines of the Copper Queen Consolidated Mining Co. will be open to inspection.

3. Globe-Miami District. The Inspiration Consolidated Copper Co. produces only copper concentrates, the ore containing small amounts of gold and silver, but too little to bring a commercial return to the company. The ore is a chalcocite disseminated through a schist gangue. The rate at which they are mining and milling at present is 16,000 tons per day, the largest output of mine to date for one day being 19,600 tons. The output of copper for the past two months has been 10,500,000 lb. per month. The run of mine ore is ground to pass a 48-mesh screen, after which it is subjected to flotation treatment, the sand tailings from flotation being further treated on concentrating tables. The concentrates are partially dewatered in Dorr tanks, and later put through Oliver filters. These concentrates are shipped to the International smelter, located 1 mile from the Inspiration mill, where they are smelted in reverberatory furnaces, the matte being treated in converters of the Great Falls type. The product is shipped to the Raritan, N. J., works of the International Smelting Company. Before going to the reverberatory furnaces the concentrates are put through a drying plant of Wedge furnaces. This drying plant is equipped with Cottrell dust collectors, and the converter gases are also passed through another Cottrell dust collector.

The International Smelting Co., which completed its plant at Miami in May, 1915, is a subsidiary of the Anaconda Copper Mining Company. It was designed, primarily, to treat the concentrates of the Inspiration Consolidated Copper Company and the Miami Copper Company. About 70 per cent of this material is a flotation product which is delivered to the plant in the form of a soft mud. After passing the dryers, it takes the form of an impalpable powder, so the handling of the original material and preventing mechanical loss later is rather difficult.

The plant has four principal metallurgical departments: I. Receiving, sampling, bedding and reclaiming. II. Drying. III. Reverberatory smelting. IV. Converting.

All fluxes and secondaries are crushed to at least $\frac{3}{4}$ in., and the proper mixture for smelting is made in the bedding bins.

Five fire-hearth Wedge mechanical roasters, 22 ft. 6 in. in diameter, burning oil, are in operation for drying and heating the charge. As it is not profitable to eliminate any of the sulphur, the temperature here is kept rather low.

Two oil-fired reverberatories, 21 ft. by 120 ft., with mechanism for changing the entire tonnage at the side walls, are in operation. Three 713-hp. Stirling boilers, in parallel, are used with each furnace. An extra furnace is in reserve.

At the converter plant are five stands with the 12-ft. Great Falls type of shells, two straight-line casting machines, and a McGregor skull-breaker.

The solid charge handled by furnaces per day is 1125

tons, 877 tons of which is concentrates. The copper content of the new material is 281.5 tons, with 9 ounces of gold and 780 ounces of silver, producing 275 tons of copper, 8 ounces of gold and 700 ounces of silver.

The property of the Miami Copper Company, located 7 miles west of Globe, Ariz., comprises an ore body of chalcocite disseminated in schist, a combined water and flotation concentrator, a concentrate-handling plant, a reclaimed-water plant and a fuel-oil power plant. The current production is about 50,000,000 lb. of copper per annum.

The ore body is composed of Pinal schist, intermixed with granite porphyry and overlain by about 200 to 300 ft. of silicified capping. The mineral occurs as partially oxidized chalcocite finely disseminated throughout the schist and porphyry. The present ore reserves are about 18,000,000 tons of high-grade sulphide ore, averaging about 2.40 per cent copper and 17,000,000 tons of low-grade primary ore. Mining is conducted by underground workings, using shrinkage stoping and top slicing methods. The ore is hoisted by balanced Kimberly skips of 7-ton capacity from a depth of 400 and 500 ft.

The concentrator is of steel and concrete construction, and comprises a coarse-crushing plant and six independent grinding and concentrating sections, with an initial capacity of 3000 tons of ore per twenty-four hours, which has been increased to 5000 tons. Coarse-crushing is performed by Kennedy gyratory crushers and Traylor rolls, and fine grinding by Hardinge conical ball mills. Concentration is performed with Deister sand and slime tables, followed by flotation, using Callow flotation cells. Ratio of concentration is about 25 to 1.

Water for concentration is obtained from the Old Dominion mine, 7 miles distant, and is partially reclaimed by means of sixty-four concrete settling tanks. About 75 per cent of the water used in milling is thereby reclaimed.

Concentrates are laundered to a concentrate-handling plant, comprising twelve vacuum dewatering tanks. Belt-conveyors communicating with these tanks transfer the concentrates, after drying, to 60-ton steel concentrate cars for shipment to the neighboring plant of the International Smelting Company.

The power plant, located adjacent to the town of Miami, is a steel and concrete structure, and comprises a boiler plant containing five batteries of 600-hp., oil-fired boilers, and an engine house containing three 1000-kw., triple-expansion engines, two 4000-cu. ft., triple-expansion air compressors, and condensing apparatus.

The Old Dominion Copper Mining & Smelting Co. has a new 700-ton concentrating mill which was put in operation about two years ago. As a result of the improvements made in the new plant the percentage recovery of copper was raised from 73.55 in 1914 to 85.27 in 1915. Grinding is done with Hardinge conical and Marathon mills; pulps are classified in Deister cone classifiers and concentrated on Deister tables and Senn pan-motion vanners. A 16-cell, 300-ton Minerals Separation flotation machine has been in use for some time, and other types of flotation apparatus are being tested. An Oliver filter is used to dewater the flotation concentrate. The smelting plant consists of blast furnaces only. The Great Falls type of basic-lined converter is used, and a remarkable cost record has been made. One shell was in service continuously for over thirty months, producing 70,860,000 lb. of copper bullion. The lining cost was 5 $\frac{1}{2}$ cents per ton of bullion, as compared with a cost of \$1.80 per ton with the old acid-lined shells. A feature of the power plant is a Diesel oil engine and generator.

X. Ray. Ray Consolidated Copper Co. mines may be visited on a side-trip from Globe. The company's mill is at Hayden, near the smelter of the American Smelting & Refining Company.

Z. Jerome-Clarkdale District. This region of Arizona is prominent through the operations of the United Verde Copper Co., with mines at Jerome and a new smelting plant at Clarkdale. The capacity of the Clarkdale plant is about 3000 tons of charge daily, and production amounts to 5,000,000 pounds of copper per month, in which is contained a small amount of gold and silver. The principal metallurgical departments are (1) crushing and sampling; (2) roasting; (3) blast-furnace and reverberatory smelting; (4) converting. The roasting equipment comprises eight 6-hearth Wedge roasters, 21 ft. 6 in. diameter. In the smelting department there are four 48 in. by 320 in. blast furnaces with Giroux hot-blast tops, and three 19 ft. by 100 ft. oil-fired reverberatories. The converting equipment consists of five stands of 12-ft. Great Falls type basic-lined converters. Further data on the operation of this plant will appear in a later number of this journal.

The Copper Chief mine, operated by the Hayden Development Co., near Jerome, has a new cyanide mill of 125 tons daily capacity. Ore is crushed by Blake crusher, ball and tube mills, the latter in closed circuit with a Dorr classifier. Continuous counter-current decantation is practiced, using Dorr agitators and thickeners with Oliver filters at the end of the system. The customary zinc boxes are used for precipitation, and the product is melted in a Steele-Harvey furnace. The entire mill is electrically driven by power obtained from the Arizona Power Company's plant at Fossil Creek.

Other Metallurgical Centers

A. Pearce. The cyanide mill of the Commonwealth Mining & Milling Co. is located here. Ore is crushed first in gyratories and then thirty 1550-lb. stamps. Classification is given in Caldecott cones and Dorr classifiers, and further grinding is done in Hardinge conical mills and tube-mills. Continuous counter-current decantation is practised, using Dorr thickeners and Pachuca agitators. Oliver filters and Merrill zinc-dust precipitation complete the equipment.

B. Clifton-Morenci-Metcalf District. Three large copper companies operate in this important district. The Arizona Copper Co. has concentrating and smelting plants which will be the subject of a paper to be presented at one of the technical sessions.

The Detroit Copper Mining Co. produces about 19,000,000 pounds of copper annually. Run of mine ore is reduced by one Gates gyratory crusher and two Symons disc crushers to 1-in. size. This product is fed at the rate of 1500 tons to the two-unit concentrator.

The mill feed is reduced by rolls to pass a four-mesh screen and is then treated to a succession of wet concentrations as follows:

Total mill feed through four-mesh is treated on Butchart national tables, the tailings of which are deslimed in shovels. The fine product (slime) of these shovel wheels is primary slime. The coarse product is reduced to $1\frac{1}{2}$ millimeter by means of Monadnock and Marathon mills. The product of these mills is separated by means of Dorr classifiers into coarse sand, fine sand and slime; the coarse sand is treated on Butchart National tables, the fine sand on Frue sand vanners, and the slime overflow, united with primary slime mentioned above is treated by flotation machines of the Rork type.

Flotation reject is cleaned up by a system of Frue

sand vanners. Total mill concentrates are dried by vacuum tanks and shipped to smelter. The tailings are dewatered in Dorr tanks and the clear water returned for further use.

Concentrates are delivered to the smelter which consists of one 500-ton blast furnace. The matte is then delivered to three barrel-type converters. The product is sold as casting copper.

The Shannon Copper Co. is the third concern operating in this district and has a copper concentrating mill and smelting plant.

C. Hayden. The American Smelting & Refining Co. operates a smelting plant of 25,000 tons monthly capacity, producing 8,000,000 lb. blister copper per month. The bullion contains some gold and silver. The principal departments are sampling, roasting, reverberatory smelting and converting. The equipment consists of eight McDougall roasters, two reverberatory furnaces, two Peirce-Smith and one Great Falls type converters and one Walker casting machine.

In the same vicinity is the concentrating mill of the Ray Consolidated Copper Co., which is about 18 miles distant from the mines at Ray. The present capacity is 10,000 tons per day, and the principal metal is copper, although the ore contains a small amount of silver. Coarse crushing to 1-in. size is done at the mine and further reduction is made at the mill with Garfield rolls and Chilean mills. Concentrating equipment consists of Garfield roughing tables, Wilfley tables and slime vanners.

D. Superior. At this point the Magma Copper Co. is conducting experimental operations in the concentration of copper and zinc ores. The copper concentrator is handling about 200 tons of ore per day which is delivered from the mine by a Bleichert aerial tramway. A variety of crushing and grinding machines are in use, comprising Blake crusher, Symons 24-in. disc crusher, Marcy ball-mill and Chalmers & Williams tube-mill. The crushed pulp is concentrated over roughing tables, and by flotation in Callow pneumatic cells. The tailings from the latter are reconcentrated on Wilfley tables. The 50-ton zinc concentrator uses the same types of crushing and grinding apparatus, Callow flotation cells and Deister double-deck tables.

E. Wickenburg. The cyanide mill of the Vulture Mines Co. gives some distinction to this point in Arizona by reason of having been one of the first to make a commercially successful use of the continuous counter-current decantation system of cyaniding. More modern mills have since used the process in greater refinement. This plant is small, having a capacity of but 75 tons per day.

F. Humboldt. The Consolidated Arizona Smelting Co. has copper smelting and concentrating plants at this place. The concentrating equipment and practice were discussed in this journal, Dec. 1, 1915, p. 897. Data on reverberatory smelting appeared Jan. 1, 1916, p. 33. Improvements in both plants have been made since that time, increasing capacity and efficiency. The introduction of flotation, together with other changes in the mill, increased recovery of copper by more than 20 per cent over the best saving previously made with jigs, tables and vanners.

The principal features of the mill, described in the article mentioned above, are grinding with Hardinge mills and the use of the Minerals Separation flotation process. The smelting equipment consisted of one 7-hearth Wedge roaster, 21 ft. 6 in. diameter; one 19 ft. by 60 ft. and one 19 ft. by 100-ft. oil-burning reverberatory furnaces; two stands of 9 ft. 6 in. barrel-type basic-lined converters.

G. Goldroad-Oatman District. This part of Arizona has recently attracted considerable attention by reason of the remarkable discoveries of gold and silver ore in a region where two companies had operated for a number of years. The **Gold Road Mines Co.** has a 350-ton cyanide mill, using stamps and tube-mills for grinding, and continuous counter-current decantation with Dorr thickeners and Pachuca agitators. Precipitation is by means of zinc dust. The **Tom Reed Gold Mines Co.** at Oatman has a similar mill of 200 tons daily capacity, with practically the same equipment. Among the newer mills projected in the Oatman district is that of the **United Eastern Mining Co.** The tentative flow-sheet shows crushing with gyratories, ball-mills and concave mills, the latter in closed circuit with Dorr classifiers. Continuous decantation with Dorr apparatus follows the latest developments in that method of cyaniding, and precipitation is to be done by the Merrill zinc-dust process.

The Training of Our Captains of Industry*

BY SIR ROBERT HADFIELD

A good deal has been said, particularly in the last few months, with regard to the training of men on whom rest the responsibility to organize and direct the technical side in great industrial affairs. In my opinion neither the scientific man nor the practical man wholly fulfills the required conditions for the direction of great modern affairs. By the practical man I mean the man who has received a good secondary education, but not special scientific culture, and by the scientific man I mean the man who is completely instructed, but is a stranger to actual experience and practice.

It usually happens that the scientific man is as necessary as the practical man, but neither the one nor the other is a satisfactory organizer, because they do not unite in one head the combination of the two indispensable elements. It is therefore necessary to arrange our educational courses so as to combine the two; in other words, to find a third type of man in whom such knowledge will be united. The solution of the problem is not easy, but it is more than ever necessary that at the present time such a new type should be evolved and developed.

Until quite recently many mistakes were made, either because the scientific man had been installed in view of his special knowledge or, at the other end of the scale, the practical man was given the preference. In a general way neither of these types has been a success.

Industrial operations of every kind, and of an increasingly complex character, are developing every day, and they are also tending to be more and more technical. This is the normal consequence of the extremely rapid progress which every nation is making in the acquisition of knowledge, which in itself is constantly becoming more varied, and yet more specialized.

It is most difficult to map out a program of education which will combine both scientific and practical ideas, especially as the main functions of each of these are sufficiently defined and naturally fall into their respective spheres. The scientist has a satisfactory education in the universities. The practical man is generally contented with an ordinary high school education, and sometimes, as is well known, he has not even had the benefit of this general education.

The scientist can certainly do excellent work in his laboratory, but generally speaking, he will only be able to render these services in this one capacity, because he has not had the opportunity to adjust his theoretical

knowledge to industrial conditions. The practical man also in his vocation is able to do good work, but it is doubtful whether in these days he can ever furnish work of the highest order.

How then are we to obtain this important combination? How can we realize the combination of science and practice? The problem is admittedly most difficult, and the solution of it probably depends in a large measure on the individual character. By means of character and energy the scientist can acquire practical knowledge; that is, he can apply his scientific knowledge to practical questions. In the same way, the practical man can acquire scientific knowledge. Education will certainly help the formation of this mixed type, but it will not be created by education alone. It must be a result either of natural temperament, of faculties developed by force of character, or in certain cases through gifts transmitted by heredity.

Naturally the best path to follow is that of scientific education, but on condition that instruction furnished by practical observation is not neglected.

All things considered, the scientist will certainly be in a better position, but if he does not possess the necessary turn of mind and the natural qualities to which reference has been made, this education which should have given him a great advantage may cause his ruin. It may prevent him from attaining the height of success to which he might have reached by applying his knowledge to practical ends. He remains in the same sphere, and cannot emerge therefrom. Numerous are such cases, and numerous also the instances of non-success among men who are practical, in consequence of their lack of scientific knowledge.

While much has already been done, there is much more to be accomplished in order to succeed in generating the evolution of the type of man required by modern conditions. Many facilities are offered to the practical man by the creation of the numerous and liberally endowed sources and seats of instruction which have been installed in all countries during the last twenty-five years. There has been the work of our universities, also of the departments of applied science attached to those universities, of our schools and technical colleges, of our research laboratories, our societies and technical institutions, and finally our technical press. All these are, in this order of ideas, of capital importance.

The combination of science and practice is of the greatest importance, but it is doubtful whether it can be obtained by education alone. In order to attain the highest degree of success a man requires something even more than education; that is, above all he must show personal application and intuition.

As so much attention is being given to a wider application and more intimate combination of science with industrial research, a few special remarks may be made with reference to this side of the subject, and in this respect attention is specially drawn to the admirable advice given by the late Dr. G. Gore, F.R.S., in his book, "The Art of Scientific Discovery."

Dr. Gore himself did most important research work. For example, it was he who discovered that iron, while cooling from a high temperature—then termed "red heat," now known as the "critical iron changing point"—about 750 deg. C., and under longitudinal strain, suddenly undergoes molecular and magnetic change attended by increase of length at a particular time. This peculiar behavior of iron has been termed "Gore's phenomenon." From Gore's observations of this simple fact eventually sprang the further discovery of Sir William Barrett, F.R.S., with regard to the recalcrescence of steel, which was further followed up by the late Prof. F. Osmond in France, with such important results.

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Gore shows in his work above referred to that scientific discovery is really no haphazard matter, and that the art can be cultivated. While all may not have the same mental capacity, there are many who, by scientific study, may acquire the art to a greater or lesser degree. There is, of course, some difference between discovery and invention. Gore defines it as follows: "Discovery consists in finding new truths of Nature, while invention consists in applying those truths to some desired purpose." However, for our present purpose the two may be treated more or less on an equality. Gore points out, while he does not maintain, that important discoveries can be made by rule alone; nevertheless the process of scientific discovery can be largely reduced to order and rule. It may be interesting to note the following types of research tabulated by Gore and through which discovery and invention may be attained:

Table by Dr. Gore Showing That Discovery and Invention May be Obtained in Some of the Following Manners:

- (1) Aid to Analogy.
- (2) Hypotheses.
- (3) Analysis and Synthesis.
- (4) Application of—
 - (a) Electricity to bodies.
 - (b) Heat to substances.
- (5) Asking questions and testing such questions.
- (6) Assumptions that—
 - (a) There is a certainty of all the great principles of science.
 - (b) Complete homologous series exist.
 - (c) Converse principles of action exist.
 - (d) Certain general statements which are true of one force or substance are true to some extent of others.
- (7) Combined action of many observers.
- (8) Comparisons of—
 - (a) Facts, and collecting similar ones.
 - (b) Collections of facts with each other.
 - (c) The orders of collections of facts.
 - (d) Facts with hypotheses.
- (9) Deducting process.
- (10) Employment of new or improved means of observation.
- (11) Examination of—
 - (a) Common but neglected substances.
 - (b) Effects of forces on substances.
 - (c) Effects of contact on substances.
 - (d) Effects of extreme degrees of force.
 - (e) Extreme or conspicuous instances.
 - (f) Influence of time upon phenomena.
 - (g) Neglected truths and hypotheses.
 - (h) Peculiar minerals.
 - (i) Unexpected truths.
 - (j) Rare substances.
 - (k) Residue phenomena.
 - (l) Residues of manufacture.
 - (m) The ashes of rare plants and animals.
- (12) Extension of—
 - (a) The researches of others.
 - (b) The researches of neglected parts of science.
- (13) Inductive process.
- (14) Investigations of—
 - (a) Exceptional cases.
 - (b) Unexplained phenomena.
 - (c) Classification unexplained.
- (15) Means of—
 - (a) Converse experiments.
 - (b) Hypotheses.
 - (c) "Homologous Series."
 - (d) Instruments of great power.
 - (e) Improved methods of intellectual operation.
 - (f) Measurements.
 - (g) The method of curves.
 - (h) The method of least squares.
 - (i) The method of means.
 - (j) The method of residues.
 - (k) New instruments.
 - (l) Modes of observation.
 - (m) Observations.
 - (n) More intelligent and acute observation.
 - (o) Additional observations by known methods.
 - (p) Periodic functions.
 - (q) More refined methods of working.
 - (r) Repetition of experiments.
- (16) Simple comparisons of facts of phenomena.
- (17) Search for—
 - (a) So-called "impossible" things.
 - (b) One thing and finding another.
- (18) Subjecting series of forces or substances to new conditions.
- (19) Use of—
 - (a) Known instruments or forces in a new way.
 - (b) Improved instruments.
 - (c) More powerful instruments.
 - (d) Causes by the methods of averages.
 - (e) Coincidences.
- (20) Conditions of—
 - (a) Scientific discovery.
 - (b) Determination of the nature of a discovery contrasted with barren reasoning.
- (21) Experimentation of discovery upon art of exceptional instances.
- (22) Fundamental laws of discovery.

The word "discovery" naturally suggests "What led Columbus to discover America?" His deductive capacity must have been very great, and no doubt mentally he must have gone through more than one of those phases

described in the tabular statement arranged by Gore. The expedition of Columbus was no happy-go-lucky one, but made with a definite purpose founded on certain definite facts known beforehand. It is interesting to remember that while on his voyage of discovery and founding another continent, Columbus discovered many curious facts with regard to compass variation.

In concluding these remarks the writer of this essay hopes that at any rate some of the ideas and suggestions put forward may lead to a better understanding of what is in these modern times required to be borne in mind in the training of those who are going to be our captains of industry, also of the channels through which discovery and invention are likely to be brought about.

The Nitrate Situation

Report of Committee on Public Relations of American Electrochemical Society

The Committee on Public Relations of the American Electrochemical Society has sent the following recommendations to the President, the Secretary of the Navy, and the Secretary of War:

Inasmuch as the utilization of atmospheric or other sources of nitrogen to supplant Chilean nitrate in this country for the manufacture of explosives and as a source of fixed nitrogen for fertilizers is in many respects an electrochemical problem, the undersigned members of the Committee on Public Relations of the American Electrochemical Society, constituted of the president and past-presidents of the society, feel justified in making the following statements and recommendations:

1. We urge upon this government the necessity of providing at once eighteen months' supply, on a war basis, of Chilean nitrate, using government ships if necessary, this reserve to be stored at various strategic points.

2. Almost all of those who have intimate knowledge of the practical working of nitrogen processes are in one way or another associated with some particular process, and we know of no experts who could be considered as having a strictly unbiased mind on the subject, as the government should be in possession of accurate confidential information regarding present developments in each of the processes proposed to date in order to be able to act wisely and promptly in case of sudden emergency, we add our indorsement to the recommendation already made by the Naval Consulting Board and others, that a small committee of appointees by the President be delegated to visit each of these groups of men who control these processes and who have already intimated their willingness to furnish proper representatives of the government with full confidential data.

3. As we confidently hope that this country may never be involved in war, while thoroughly believing it should be prepared for immediate defense, it should be remembered that the great peace use of fixed nitrogen is as a plant food, and it is therefore desirable that private interests be allowed to develop the best and cheapest process on a peace basis without either government aid or government hindrance unless equally applied to all comers. We are therefore opposed to a government subsidy to any particular process at the present time, or the immediate construction of a government plant working any particular process. All of the processes can apparently be greatly improved, and the evolution of the best process will proceed more rapidly than under the artificial stimulation which government backing would give to any single process. The purchase of a suitable supply of Chilean nitrate and the possession of information upon which to base an emergency decision

advocated above will serve the purpose of military expediency without discouraging private initiative. We are, however, in favor of a liberal water power policy, as the question of the cost of power is vital to several of the processes. We believe it is in the highest degree conserving resources to make use of the otherwise wasting water power which can be conserved in no other way, and thereby preserving other sources of power, as coal, gas and oil.

4. The processes to be considered may be classified into those which produce nitric acid by direct union of the nitrogen and oxygen of the air, such as the Birkeland-Eyde and the Pauling processes; those which produce ammonia by direct union of nitrogen and hydrogen, such as the Haber process; those which fix nitrogen in a complex compound, such as the cyanamid process, and the action of nitrogen fixing bacteria in natural fertilization, and, finally, natural sources of fixed nitrogen, the only one which is of sufficient magnitude to warrant consideration is by-product ammonia derived from the distillation of coal. All of these, except the arc processes, produce ammonia, and as this and not nitric acid is the chief desideratum for fertilizer purposes, there is not sufficient commercial incentive for the carrying of these ammonias of varying degree of purity through the nitric acid required in the manufacture of explosives. All of the processes except that involving the use of bacteria have more or less active exponents in this country. We therefore urge that the research facilities of the government be concentrated upon these two points: The oxidation of ammonia and the *modus operandi* of nitrogen-fixing bacteria. This could be done with the aid of some of the government departments. Thus the Bureau of Mines should be able to investigate the oxidation of ammonia while the fixation of nitrogen by bacteria might be well studied by the Bureau of Soils.

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The Western Metallurgical Field

Geological Survey's Mid-Year Review

Following a practice begun last year, the U. S. Geological Survey has issued a mid-year review of the mineral industry, showing the remarkable accomplishment of the first six months of 1916. From these indications the forecast is made that 1916 will be a record-breaking year. Coal, iron and steel, cement and oil have experienced unusual demands, and large gains over last year's records are easily foreseen.

Most precious-metal mines are operating at full capacity. The gold production will probably fall below the high yield of last year, but silver, the one metal last to benefit by the general domestic prosperity, is expected this year to break all previous records.

In Colorado the gold production of Cripple Creek, which accounts for 60 per cent of the State's output, has fallen off appreciably, and the San Juan region has not maintained its output of 1915. From California it is reported that the U. S. Mint and local smelters and refiners are in receipt of \$366,000 less gold and 22,000

more ounces of silver during the first five months of 1916 than in the corresponding period a year ago. Nevada also will likely show a decrease in gold, due to declining production at Goldfield and the failure to discover new important deposits. Bullion receipts from Oregon mines show an increase in both gold and silver, the former being due entirely to dredging operations.

Copper is continuing the steady increase in production which began early last year, and the forecast for 1916 indicates not only the largest output ever known but also the largest profits. In Nevada the copper output has been increased more than 50 per cent, and the value at present prices will be double that of last year. Arizona will continue to hold first place among copper-producing States, producing 600,000,000 lb. of copper if production continues at present rate, which is nearly double that of any other State. In Utah the probability is that the year's production of copper will be 225,000,000 lb. The value of copper produced will be about double that of 1915.

The lead and zinc mines are producing ore at a rate even exceeding that of last year, and the prevailing prices have made possible the working of large quantities of low-grade ore. From Idaho shipments of lead are being made at the rate of 360,000,000 lb. per annum, and there will be a corresponding increase in the output of silver. Coeur d'Alene companies are shipping lead concentrates and ore at the rate of over 30,000 tons a month, and zinc material at the rate of over 8000 tons a month. No great increase in zinc is looked for in Utah, but Colorado is expected to exceed the record of 1915.

In quicksilver the outlook is for a continuance of the output of 1915, which was the largest for several years. Thus far in 1916 the average price has greatly exceeded the 1915 prices; and although the reaction in prices has come, conditions are favorable for steady and profitable operation of the quicksilver mines, some of which are newly opened.

Shipments of iron ore from Lake Superior points for five months of 1916 exceeded by more than 80 per cent those for the same months in 1915, and the indications for the year are favorable for a new high record on iron-ore production, and of pig iron as well. Higher prices with a steady demand are stimulating the mining of manganese, with the result that this year's output of ore is expected to surpass the large production of last year.

Electrolytic Zinc in Utah

Construction of the new electrolytic zinc plant for the Judge Mining & Smelting Co., at Park City, Utah, is progressing satisfactorily, the excavation and foundations having been completed. The work is being pushed with vigor in order that production may begin at an early date. When the new plant is completed it will handle about thirty tons of high-grade zinc concentrates per day and turn out about fifteen tons of electrolytic zinc. It is reported that a feature of the electrolytic work will be the use of revolving cathodes of aluminium. While other experimental work has been done on electrolytic zinc in Utah, the Judge plant will be the first to operate on a commercial scale.

Production of Platinum in California and Oregon

An increase in the production of crude platinum in California and Oregon in 1915 is reported by the U. S. Geological Survey. The official figures show an output of 741.91 troy ounces, valued at \$23,538. This is an increase of 171.91 ounces over the production in 1914. California is the principal producer, only one mine in Oregon reporting any output. Platinum refiners report that a total of 8665 troy ounces of new

metals of the platinum group was recovered, of which at least 1587 troy ounces is believed to be of domestic origin.

Secondary metals derived from the refining of scrap and sweeps to the amount of 42,970 troy ounces were sold in 1915.

Notwithstanding the embargo placed upon the exportation of platinum by all the allied governments, the United States imports of platinum and allied metals during the year 1915, as compiled by the Bureau of Foreign and Domestic Commerce, Department of Commerce, were only 10 per cent below the 1914 imports, amounting in all to over 69,000 ounces, having a value of \$2,768,688.

Figures showing the world's production of platinum and allied metals are at best estimates made from the most reliable information obtainable. The table below gives the best estimates from information available to the Geological Survey at this time:

Country	1912	1913	1914	1915
Borneo and Sumatra	200	200	(*)	
Canada	30	50	30	100
Colombia	12,000	15,000	17,500	19,000
New South Wales	778	1,275	1,248	856
Russia	300,000	250,000	241,200	124,000
United States	721	483	570	742
	313,729	267,008	260,548	143,898

*No basis for estimate.

†No figures from Tasmania available at time report goes to press.

Teck Hughes Cyanide Mill, Ontario

The Teck Hughes property in the Kirkland Lake district of Ontario is equipped with a 50-ton cyanide mill of the continuous decantation type. Primary crushing is done with a 16 in. by 10 in. jaw breaker of the Blake type, and subsequent grinding by a 5 ft. by 5 ft. ball mill. The ball-mill discharge is further ground in a 5 ft. by 20 ft. tube-mill running in closed circuit with a Dorr classifier. The slime thus produced is treated by continuous agitation and decantation in Dorr agitators and thickeners. A change of solution is made after agitation is two-thirds complete, in accordance with practice which has been explained at length in former articles in this journal. The thickeners are of the tray type which have been proving popular in recent installations. Due to the high grade of the ore and relatively high strength of cyanide solutions, a filter of the Oliver type follows the decantation system as is customary under such conditions.

Some Unusual Conditions in Oklahoma Zinc Mines

An occurrence of hydrogen sulphide in the new zinc mines of the Picher Company at Picher, Okla., constitute an unusual phenomenon that has caused some trouble in mining operations. The characteristic odor of the gas is plainly perceptible about the shafts and in the workings, and water pumped from the mines is milky with precipitated sulphur. The effect on the workmen is such that they are unable to put in a full shift without relief. Practically all the miners become affected with what is locally known as "pink eye," an affection of the membranes of the eye that causes inflammation and discomfort. In some cases the affection is so acute that the men can work only during alternate two-hour periods. Various remedies have been used, but one of the best that had been tried was the wearing of goggles that keep the gases from the eyes. The workings are ventilated by blowers and exhaust fans, the former at the shafts and the latter at drill holes connecting with the drifts. As far as is known the occurrence is localized at the properties mentioned.

Another unusual condition is encountered at the property of the Admiralty Company near Cardin. Here the ore is impregnated with a natural hydrocarbon that gives considerable trouble in milling. The ore is black in appearance and has a strong odor of mineral oil. The concentrates also have an oily appearance and odor. The chief difficulty encountered in milling was due to the clogging of the jig screens by the hydrocarbon material. This has been overcome by introducing kerosene under the screen of the first compartment of the jig, thus "cutting" the heavy oil and keeping the screens clear. Several barrels of kerosene are used per day, fed under pressure from a reservoir in the hoist house. Other oils were tried, such as gasoline, but kerosene proved most effective.

Production of Gold and Silver in the United States

The Bureau of the Mint and the Geological Survey have issued the following joint statement as to the final figures on the production of gold and silver in the United States during the calendar year 1915:

State or Territory	GOLD		SILVER	
	Fine Ounces	Value	Fine Ounces	Value ¹
Alabama	247	\$5,100		
Alaska	808,346	16,710,000	1,054,634	\$526,100
Arizona	220,392	4,555,900	5,665,672	2,826,500
California	1,090,731	22,947,400	1,830,024	843,100
Colorado	1,089,928	22,530,800	7,199,745	3,591,900
Georgia	1,628	34,800	141	100
Idaho	56,684	1,170,600	13,042,466	6,506,800
Illinois			2,892	1,900
Michigan			581,874	290,300
Montana	240,825	4,078,300	14,423,173	7,195,600
Missouri			35,334	27,700
Nevada	574,874	11,883,700	14,438,085	7,210,500
New Mexico	70,632	1,460,100	2,337,064	1,165,900
North Carolina	8,258	170,700	1,496	700
Oregon	90,321	1,867,100	125,499	62,600
Philippine Islands	63,898	1,320,900	15,145	7,600
Porto Rico	34	700		
South Carolina	174	3,600		
South Dakota	358,145	7,403,500	197,569	98,600
Tennessee	329	6,800	99,171	49,500
Texas	87	1,800	724,580	361,500
Utah	189,045	3,907,900	13,073,471	6,522,200
Vermont			150	100
Virginia	24	500		
Washington	22,330	461,600	213,877	106,700
Wyoming	672	13,900	2,910	1,400
Total	4,887,604	\$101,035,700	74,961,075	\$37,397,300

¹At the average price of silver per fine ounce for the calendar year 1915, \$0.49880.

These figures compare with the production of 1914—\$94,531,800 in gold and 72,455,100 fine ounces of silver, being a gain in the gold production of \$6,503,900 and 2,505,975 fine ounces in the silver product.

Company Reports

Alaska Gold Mines Co. made a profit of \$251,848 in 1915, being 22.581 cents per ton treated. Miscellaneous income of \$26,923 is to be added. The first section of the mill began operations on February 12, 1915, and the full average tonnage of 6000 tons per day was maintained by November. Steps were taken to increase the capacity to 12,000 tons per day. During the year 1,115,294 tons of ore was milled, having an average value of \$1.1569 per ton. Average tailings were 21.91 cents, showing an extraction of 81.06 per cent. Average total milling cost for the year was 30.496 cents, though in November the cost was but 25.699 cents. Average total net cost for the year in mining, milling and disposition of products, inclusive of all fixed and general charges was 69.039 cents per ton. The same cost in November was 59.785 cents.

Butte & Superior Copper Co. had an operating profit in 1915 of \$9,074,151, with miscellaneous income of \$51,795, making a total of \$9,125,946, as compared with \$1,417,127 in 1914. Dividends paid amounted to \$4,908,115. Under the company's contract with the American Zinc, Lead and Smelting Co., the spelter

produced from Butte & Superior Concentrates is returned to the original company for sale in open market. Owing to the fact that the word "Copper" in the company's name is misleading, and inasmuch as the chief product is zinc it is proposed to change the name of the concern to Butte & Superior Mining Co. Developed ore reserves at the end of the year were about the same as a year previous, and amounted to about 1,000,000 tons. Total ore mined amounts to 522,949 tons at an average cost of \$3.36 per ton. The flotation plant was rebuilt for the purpose of increasing capacity and increasing efficiency. An increase in capacity 60 per cent greater than in 1914 was brought about without extensive additions to plant. Total ore milled amounted to 522,300 tons, but late in the year the average was 50,000 tons per month or at the rate of 600,000 tons per year. Average zinc content of ore milled was 17.02 per cent; of silver, 7.63 ounces per ton. Mill recovery averaged 92.21 per cent, but for the last quarter it was 95.07 per cent. Average cost of milling was \$1.75 per ton, as compared with \$2.12 for 1914.

The Iron and Steel Market

The steel market has turned distinctly stronger in the first half of August, a reflection in part of the remarkable stability it showed during June and July when in the face of very light demand prices were held very firmly and the mills appeared to be quite indifferent as to whether or not they booked additional business, and a reflection also of the heavier demand for shell steel than had been expected.

The new development of August is that resistance to weakness has given way to a positive exhibition of strength. The new movement started with the official announcement on the afternoon of August 1 that the Carnegie Steel Company had advanced its price on merchant steel bars \$2 a ton, from 2.50c. to 2.60c. The independents began quoting the advanced price in a limited way, while they closed at 2.50c. such pending negotiations as could be brought to a head, and the market is now practically established on the higher basis. Structural shapes showed a tendency to move up in harmony with bars even though on account of the peculiar alignment of demand for different products at this time the demand for shapes is relatively light while the relative demand for bars is abnormally heavy. Plates are now predicted for a rise also, and wire products are moving upwards.

Buying of steel in the domestic market goes by movements and a movement must have an exciting cause, such as price advances or mills falling farther behind in deliveries. The last buying movement began to wane in March and came to an end in May, since which time the buying has been spasmodic and sporadic in character. At the beginning of June the balance of probability seemed to be that there would not be another buying movement until there had been a readjustment in prices, and in some quarters it was thought far from improbable that the market would weaken toward the close of August or in September, not because the large mills would not get additional business but because the small mills presumably would, since customarily they do not sell far ahead. The small mills are now found to be in strong position, however. As time has passed predictions have begun to appear that a fresh buying movement of some proportions would start in the fall, presumably in September, and the events of the past fortnight have tended to strengthen the expectation.

Export and War Demand

A strong factor in the further stiffening in the steel situation has been the unexpectedly heavy demand for

steel for export and for shell manufacture. There was heavy buying of shell steel in April and May and at the close of May it was rather thought that substantially all the business for the second half of this year had been placed. The buying has, however, continued on a large scale. In the past thirty days it appears that more than half a million tons of shell steel has been placed, with negotiations for a considerable tonnage still pending. The recent business involves a larger percentage of shell steel to be shipped abroad in the form of rolled rounds and forging billets, as the capacity for making shells abroad, particularly the smaller shells, has been rapidly increasing. There is a large decrease in the manufacture of small shells in the United States, but the manufacture of large shells is increasing, and on the whole it would appear that the production of shell steel is increasing, though possibly a somewhat smaller tonnage will be converted into shells in this country.

Apart from this movement in shell steel there is continued heavy demand for soft steel for export, apparently because the steel works abroad are diverting more of their capacity to the manufacture of shell quality, involving a greater call upon the United States for soft unfinished steel. As a result of these conditions the market for soft steel billets and sheet bars is a trifle stronger than at any previous time in this movement.

Production Decreased

Since the first of July the production of pig iron has been at a rate of about 38,250,000 tons a year, contrasting with the high rate of 39,800,000 tons attained in May. The chief factor in reducing the output has been the extremely high humidity, much above the normal even for July and August. A smaller but hardly a negligible factor has been the necessity of blowing out quite a number of furnaces for relining, more furnaces having gone out since July 1 than have gone in. It is quite evident that the furnace performance last spring was abnormally good and it seems certain that the existing furnaces cannot for a twelvemonth maintain an average rate of 40,000,000 tons. The maximum rate attained before this movement was 34,000,000 tons, in March and April, 1913, and not more than half the increase in the rate to last May can be attributed to the completion of new furnaces. Scarcely any new stacks will come in during the balance of this year and while about twenty-five new furnaces are being built it seems improbable that all will be completed by the end of 1917.

The very hot weather has decreased steel mill operations more than pig iron output, the production of finished steel being reduced, from the June rate, by more than 10 per cent, and thus pig iron has not grown scarcer, though it may do so later in the year.

Pig Iron

Pig iron has been stagnant in all districts, buyers apparently being well covered. Occasionally interest is manifested in foundry iron for the first quarter or first half of 1917 but the furnaces are indisposed to quote, feeling that the balance of probability is that prices will be higher later in the year. In some quarters a buying movement is predicted for September, chiefly on the ground that as steel making capacity is being increased by various additions there will be more iron needed than has already been provided. Some of the large steel interests, normally self-contained, may enter the market.

Steel

Soft steel is strong at a general level of about \$45 for either billets or sheet bars. While Bessemer may be

a shade lower than open-hearth there seems to be little distinction at this time. Rods are \$55 to \$60, with high carbon rods commanding unusual premiums over mild steel grade.

Production of Tin Plate and Galvanized Sheets

Statistics have just been made public showing the production in 1915 of tin plates, terne plates and galvanized sheet products, the comparison being as follows, in gross tons:

	Tin Plate	Terne Plate and Terne	Total Tin and Terne	Galvanized Sheets	Galvanized Formed Products
1912	962,971	61,134	823,719	824,047	51,674
1914	865,978	65,286	931,241	806,994	58,752
1915	982,958	72,978	1,055,936	706,058	50,119

The previous record year for tin and terne plate production was 1912, with 962,971 tons. The decrease in galvanized sheet production in 1915 is less than would have been predicted as the high-priced spelter reached before the middle of the year eventually caused a large decrease in galvanizing operations. The mills evidently operated on relatively cheap spelter for a while after the top was reached in the spelter market in June.

The Non-Ferrous Metal Market

Copper.—There has been little doing in the past two weeks in copper. The market remains firm, however, as it is pretty well sold up. Electrolytic was quoted on Aug. 11, at 26.50c. for spot and August deliveries, New York, with futures at 26c. Lake is quoted at 26.75c. spot.

Tin.—This market has been generally quiet. There is a large supply of Banca tin on hand which was quoted on Aug. 11, at 36.25c. New York, when Straits was held at 37.67½c. for spot. Deliveries to consumers in July amounted to 4432 tons.

Lead.—On Aug. 2 the American Smelting & Refining Company reduced its price from 6.50c. to 6 cents New York, a reduction which was generally expected, and which was thought would bring large business. The reduction did not stimulate buying to any great extent, however. Independents are asking 5.95c. New York.

Spelter.—This metal is dull and weak with little business done. Spot spelter was quoted on Aug. 11 at 8.50c. New York, while 7.75c. was asked for November and December delivery.

Other Metals.—Antimony continues downward and 11c. is quoted for Japanese and Chinese. Aluminium is quoted at 58c. to 60c. for No. 1 virgin metal. Platinum is quoted at \$60 per ounce; Magnesium at \$3.50 per pound; Quicksilver at \$75.00 per flask, with silver at 66¼c.

Coming Meetings and Events

American Institute of Metals and American Foundrymen's Association, Foundrymen's Convention, Cleveland, Sept. 11-16.

American Institute of Mining Engineers, Arizona, Sept. 18-23.

Mining and Metallurgical Society of America, New York Section, New York, Sept. 21.

Second National Exposition of Chemical Industries, New York, Sept. 25-30.

American Chemical Society, New York, Sept. 25-30.

American Electrochemical Society, New York, Sept. 28-30.

Technical Section, American Paper and Pulp Association, New York, Sept. 25-30.

American Institute of Chemical Engineers, New York, Jan. 10-13, 1917.

Technical Societies and the Second National Exposition of Chemical Industries

The society meetings and the Second National Exposition of Chemical Industries which are to be held in conjunction with each other in New York from Sept. 25 to 30, provide a week of great interest and value to the chemical industries and to all those interested in chemistry. It is a combination which no one so interested can afford to miss.

The American Electrochemical Society has planned a series of very interesting sessions for its thirtieth general meeting, which will be held during the week of the show on Sept. 28, 29 and 30. The meeting will be opened on Thursday with the "Made in America" technical session devoted to a review of American progress in the electrochemical industry. A complimentary smoker will be held on Thursday evening to which members of the American Chemical Society, and other visiting engineers are invited, and on Friday evening there will be a joint banquet at the Waldorf-Astoria of the members of the American Chemical Society, The American Electrochemical Society, and the Technical Association of the Pulp and Paper Industry. This will be a subscription banquet and the price of tickets to members will be \$3.50; additional tickets for guests will be obtainable at cost, or about \$7.

The first general session of the American Chemical Society will open at Columbia University on Tuesday morning, Sept. 26, and arrangements are being perfected for a public meeting in the large hall of the College of the City of New York on Tuesday afternoon, when addresses will be made of general public interest pertaining to the interesting developments in the field of applied chemistry during recent years. More detailed announcements will be given in a later issue.

Dr. Charles H. Herty, of the University of North Carolina, president of the American Chemical Society, will open the exposition on Monday, Sept. 25, at 2 o'clock in the afternoon, with an address reviewing the history of chemistry and the chemical industries in this country and outlining developments since the outbreak of war in Europe.

On Aug. 1, 1915, there were thirty-seven pledged exhibitors to the First National Exposition of Chemical Industries. On Sept. 20, 1915 the Exposition opened with eighty-three exhibitors.

On Aug. 1, 1916, there are 125 pledged exhibitors to the Second National Exposition of Chemical Industries—an increase of nearly 350 per cent. By Sept. 25 of this year the management expects to have the third floor of the Grand Central Palace filled. Out of the eighty-three exhibitors of last year all but four will exhibit again this year. Last year there were 63,377 admissions to the Exposition—this year it is not unreasonable to expect an attendance of 100,000.

Appliances and equipments used in the whole range of American chemical industry will be shown.

While it is utterly impossible to show large processes in actual operation yet the equipments used will be on exhibition and there will be men present, expert in their various lines to explain. One great section of the Exposition will be devoted to the paper industry. The dye-stuff industry will be extensively represented. There will be shown what has been accomplished in America in the production of potash. An interesting feature will be a demonstration of the ultra-microscope. The great natural resources of the United States and Canada will be vividly shown. Many chemical processes, that could not be demonstrated in actual operation in such a building as the Exposition will be shown in motion pictures.

The Working Efficiency of Rolling Steel

BY SIDNEY CORNELL

Descriptive matter in relation to the blast furnace, the open-hearth, and the rolling mill is abundant in technical magazines, but the human side of the art is rarely touched upon by any writer, either in America or in Europe. Technical men have given us many valuable articles from a purely scientific standpoint, and one author states that metallurgical progress in connection with the blast furnace has not been what it should have been, due to the fact that the authors of articles are inclined to write lop-sided heat balances rather than devote their time to mechanical problems.

This may be true, but all progress costs money, and the money seldom comes from the man who operates the various metallurgical apparatus, single units of which may cost as much as \$1,000,000 to build and \$2,500,000 per year to operate. Another and deeper side of the problem, therefore, presents itself, the basis of which is accounting.

The accounting of the steel works industry has not yet been approached in such a detailed way as to make it truly scientific, I may safely state that steel works accounting is usually a most lop-sided affair of lumped expenditure and lumped returns, yielding a fair profit or otherwise, but usually the former.

Efficiency involves detail, and the attendance to detail will reward its followers sooner or later. In this article I will present not a series of accounting methods, but a compilation of observations involving details, each detail in turn often involving further details, but leading up to the unknown quantity of what it really costs to make steel.

In many ways the steel industry practices material efficiency of a high order. Metal is produced in a fair degree of efficiency as far as yield is concerned and it is possible to follow the process visually in the transformation of iron ore to finished steel article. In this transformation the money expended can reach surprising figures, and the steel works early became efficient in the utilization of all scrap material. However, they have never known what the value of that scrap material was, and have apparently never cared. In the following I wish to present observations which will bring out in a simple manner the real cost of making steel.

My figures are taken from many sources, but I am confining the discussion to a steel plant containing blast furnaces, open-hearth furnaces, bloomers, billet mills, and merchant mills, and all of the auxiliaries needed in such a plant. Some of the cost units used would be higher and others would be lower for other localities, and for any specific case these changes would have to be duly considered, but the working of the method is plainly evident. A plant located some twelve miles from Pittsburgh is taken as representative.

The plant covers 150 acres of land, and includes six blast furnaces, thirty-two open-hearth furnaces, a 38-in. and a 40-in. blooming mill, a rail mill used to roll light shapes, billets, and sheet bar, and continuous mills, arranged so that the product of the 38-in. mill passes through the rail mill and continuous mill and so that the product of the 40-in. mill may be passed through another continuous mill. Secondary to these are five merchant bar mills, namely a 22-in., a 13-in., two 10-in. mills and an 8-in. mill. For convenience the above mills are here called 1A Bloomer (38 in.); 2A Bloomer (40 in.); 1B rail mill; 1C the one 14-in. continuous mill; 2B the other 14-in. continuous mill. The merchant mills are called 1M (10 in.), 2M (13-in.), 3M (8 in.), 4M (10 in.), and 5M (22 in.). The value of such a plant, bought

piecemeal, and involving great improvements from time to time with the writing off of values, makes the subject of overhead a difficult one and the only way to arrive at any figures worth considering is to give present working values comparatively.

The product of such a plant for an average month is tabulated in Table I.

TABLE I—DISTRIBUTION OF STEEL AND IRON IN THE VARIOUS DEPARTMENTS FOR AVERAGE MONTH

Part of Mill	TOTAL CHARGED		Product		SCRAP METALLURGICAL		Losses, Etc.	
	Am't Tons	Per Cent	Am't Tons	Per Cent	Am't Tons	Per Cent	Am't Tons	Per Cent
Blast furnaces	80,100	...	80,100	...				
Pig to O. H.	64,500	...	64,500	...				
Pig sold	15,600	...						
Open hearth	116,000	100	103,200	88.96	8,000	5.17	8,800	5.87
Castings	300	...	300	...				
Steel to mills	102,900	...	102,900	...				
1A Mill	66,000	100	56,800	86.06	8,000	12.12	1,200	1.82
1B Mill	56,800	100	54,000	95.07	2,500	4.40	300	.53
1C Mill	14,100	100	13,000	92.20	1,000	7.09	100	.71
2A Mill	36,900	100	29,200	79.13	7,100	19.24	600	1.62
2B Mill	10,500	100	9,700	92.38	750	7.14	50	.47
1 M. Mill, 10 in.	8,000	100	7,200	90.00	650	8.12	150	1.88
2 M. Mill, 13-in.	9,000	100	8,000	88.88	900	10.00	100	1.12
3 M. Mill, 8-in.	1,550	100	1,400	90.32	125	8.06	25	1.62
4 M. Mill, 10-in.	2,800	100	2,500	89.28	250	8.93	50	1.79
5 M. Mill, 22-in.	8,500	100	7,400	87.06	1,000	11.76	100	1.18
Special product of Merchant Mill	2,200	100	2,150	97.72	50	2.27		

The material efficiency of the various mills is shown in the column per cent under product. The net efficiency from a material standpoint is derived as follows:

The 102,900 tons of steel delivered to the mills are first rolled in mills 1A and 2A. Sixty-six thousand tons rolled in 1A, give 56,800 tons of product, which is rerolled in 1B mill, yielding in turn 54,000 tons of product, and from this 14,100 tons are rolled in 1C mill, giving 13,000 tons of product, so that out of the 66,000 tons rolled on in 1A mill, the product is $39,900 + 13,000 = 52,900$ tons.

The 2A mill rolls on 36,900 tons giving 29,200 tons from which 10,500 tons are rolled on in 2B mill, so that the net product from this side is $18,700 + 9,700 = 28,400$ tons.

The total product of mills 1A and 2A is thus $52,900 + 28,400 = 81,300$ tons, in the form of blooms, billets, sheet bar and light shapes. From these 81,300 tons there must be taken 29,850 tons of blooms and billets for mills 1M to 5M, leaving 51,450 tons for sale. These 29,850 tons give 26,500 tons of product. From this product 2200 tons are used to furnish 2150 tons of finished specialty, while the remaining 24,300 tons are saleable in the form of merchant bar.

The saleable product of the above steel plant is thus:

	Tons
Pig iron	15,600
Blooms, billets, sheet bar	51,450
Merchant bar	24,300
Special merchant bar product	2,150
Castings	300

or 15,600 tons of pig iron, and 78,200 tons of finished and semi-finished steel. As 116,000 tons of metal were charged to the open hearth and 78,200 tons of product were finally obtained, the material efficiency of the conversion is 67.4 per cent. During this conversion a total of 28,325 tons of metallic scrap is produced, together with 9475 tons of roll scale, cinder, etc., all of which must be remelted in the open hearth or blast furnace. It is quite obvious that the cost of this scrap and scale is not what the market value would be, and it is upon this point that the following tabulations rest.

In order to arrive at a basis for figuring the real

efficiency of a steel plant it is first necessary to consider all of the non-producing departments connected therewith and accordingly I am tabulating these departments as follows, using a decimal system of numbering.

The non-producing departments are a matter of simple accounting and each producing department bears the burden in exact proportion to the service rendered.

Account 1—Steam.	
“ 2—Water.	
“ 3—Electrical.	
“ 4—Transportation.	
“ 5—Maintenance shops.	
“ 6—Roll shop.	
“ 7—Laboratory.	
“ 8—Store rooms.	
“ 9—General works.	

The last item General Works is the only one that serves generally and the sum so expended must be distributed in proportion to the tonnage of the various producing departments.

The above nine accounts are dealt with in Tables II to X.

The average conditions for the production and utilization of steam for an average month's account is as follows, steam costing \$2.60 per boiler horsepower, month.

TABLE II—STEAM. ACCOUNT 1

Part of Mill	B.H.P.	Cost
Blast furnaces, steam consumed.	8,000	\$20,400.00
Steam sent to steel works from B. F.	9,100	.....
Steam generated in steel works.	4,670	.....
Total steam used in upper works.	13,770	35,800.00
Water, Steam used.	660	1,720.00
Electrical power.	2,175	5,650.00
Open hearth.	685	1,775.00
1A mill.	2,500	6,500.00
1B mill.	3,450	8,970.00
1C mill.	1,400	3,640.00
2A mill.	2,600	6,760.00
2B mill.	300	780.00
Total.	13,770	\$35,800.00
1M mill.	745	1,940.00
2M mill.	600	1,560.00
3M mill.	385	1,000.00
4M mill.	415	1,080.00
5M mill.	1,475	3,840.00
Special product.	100	260.00
Total.	3,720	\$9,880.00
Boiler horsepower. Coal fired.	8,390	
Boiler horsepower. Gas fired.	17,100	
Total	25,490	
Coal used = 10,500 tons		
Water used = 64,100,000 gallons		

Average conditions for water for average month with distribution in 1000 gal., and at a cost of \$0.004 per 1000 gal. pumped is given in Table III. Water for boilers excluded as cost appears in steam.

TABLE III—WATER. ACCOUNT 2

	1,000 Gallons	Cost
Blast furnaces	1,280,000	\$5,120.00
Open hearth.	175,000	700.00
1A mill.	30,000	120.00
1B mill.	50,000	200.00
1C mill.	25,000	100.00
2A mill.	40,000	160.00
2B mill.	25,000	100.00
1M mill.	20,000	80.00
2M mill.	20,000	80.00
3M mill.	10,000	40.00
4M mill.	10,000	40.00
5M mill.	30,000	120.00
Total.	1,715,000	\$6,800.00

Average conditions for average month, distributed in kilowatt-hours, at a cost of \$0.005 per kilowatt-hour.

TABLE IV—ELECTRICAL POWER. ACCOUNT 3

	Kilowatt-Hours	Cost
Water.	145,000	\$725.00
Blast furnaces	350,000	1,750.00
Open hearth.	275,000	1,375.00
1A mill.	100,000	500.00
1B mill.	65,000	325.00
1C mill.	15,000	75.00
2A mill.	45,000	225.00
2B mill.	15,000	75.00
1M mill.	100,000	500.00
2M mill.	40,000	200.00
3M mill.	60,000	300.00
4M mill.	200,000	1,000.00
5M mill.	50,000	250.00
Shops.		
Total.	1,560,000	\$7,800.00

TABLE V—TRANSPORTATION. ACCOUNT 4

Blast furnaces.	\$10,000.00
Open hearth.	5,000.00
1A mill.	1,100.00
1B mill.	500.00
1C mill.	600.00
2A mill.	500.00
2B mill.	300.00
1M mill.	200.00
2M mill.	400.00
3M mill.	200.00
4M mill.	400.00
5M mill.	200.00
Spec. product.	200.00
Total.	\$19,300.00

TABLE VI—MAINTENANCE SHOPS. ACCOUNTS

	Machining Shop	Blacksmith Shop	Boiler Shop	Pipe Shop	Carpenter Shop	Millwright Shop	Brick Layers	Electricians	Painters	General Labor	Total	
General works	175	10	60	15	200	20	120	50	40	25	\$1,545	
Steam	700	10	700	450	90	30	400	20	75	350	2,435	
Water	10	10	20	500	100	150	100	15	75	250	1,845	
Electricity	10	10	10	10	50	10	675	50	10	75	840	
Transportation	1,650	250	375	75	150	50	50	50	1,500	4,100	80	
Laboratory	3,300	440	1,050	585	645	170	790	825	6,250	14,115		
Blast furnaces	1,250	515	685	160	845	65	2,940	1,125	20	1,700	9,285	
Open hearth	1A Mill	950	420	260	115	265	100	1,225	315	10	150	3,810
	1B Mill	700	280	175	80	175	80	250	210	10	125	2,535
	1C Mill	250	145	90	35	90	40	475	105	5	100	1,335
	2A Mill	500	245	200	120	170	85	450	260	5	150	2,185
	2B Mill	150	65	30	30	35	75	140	30	5	100	660
	1M Mill, 10-in.	160	25	65	40	40	10	35	125	5	150	655
	2M Mill, 13-in.	185	45	100	50	30	10	35	110	5	200	770
	3M Mill, 5-in.	30	5	25	5	15	5	25	10	50	170	
	4M Mill, 10-in.	40	5	30	5	15	5	25	10	50	185	
	5M Mill, 22-in.	150	65	65	40	40	10	90	155	10	200	825
Total, dollars	10,240	2,545	3,920	2,315	2,955	905	7,620	4,090	200	11,650	46,440	

TABLE VII—ROLL SHOP. AVERAGE CONDITIONS FOR AVERAGE MONTH. LABOR AND MATERIAL. ACCOUNT 6

1A mill.	\$1,200.00
1B mill.	3,500.00
1C mill.	1,300.00
2A mill.	1,000.00
2B mill.	750.00
1M mill.	300.00
2M mill.	600.00
3M mill.	300.00
4M mill.	300.00
5M mill.	1,500.00
Total.	\$10,750.00

Laboratory account includes physical inspection as well as chemical control. Rejections to the amount of about 3.0 per cent of the product (which goes into scrap) are made through the laboratories.

TABLE VIII—LABORATORY. ACCOUNT 8

Blast furnaces.	\$2,000.00
Open hearth.	1,400.00
Soaking pits.	35.00
1A mill.	50.00
1B mill.	25.00
1C mill.	40.00
2A mill.	25.00
2B mill.	75.00
1M mill.	75.00
2M mill.	75.00
3M mill.	75.00
4M mill.	75.00
5M mill.	75.00
Total.	\$4,025.00

Distribution of all supplies and materials used in repairs, less any credit for salvage of material. Applies to mills only, the other stores being absorbed in the blast-furnace and open-hearth charges to follow:

TABLE IX—STORE ROOMS. ACCOUNT 9

1A mill	\$7,400.00
1B mill	2,700.00
1C mill	1,300.00
2A mill	5,850.00
2B mill	700.00
3M mill	750.00
3M mill	850.00
4M mill	400.00
4M mill	500.00
5M mill	1,250.00
	\$21,700.00

In the plant under discussion some \$28,000 per month would be expended for General Works, including the following. The taxes would amount to some \$100,000 per annum, but dependent upon local conditions, so that \$8,300 for taxes would have to be added to the monthly overhead. Itemized this would appear somewhat as follows:

TABLE X—GENERAL WORKS. ACCOUNT 9

1 Executives' salaries	\$9,500.00
2 Stationery	1,600.00
3 Postage	250.00
4 Furniture	200.00
5 Office expense	1,000.00
6 Telephone and telegraph	600.00
7 Drafting and engineering	3,000.00
8 Special departments	2,500.00
9 Watchmen and gatemen	2,500.00
1 Shop cost	545.00
2 General maintenance	3,000.00
3 Store rooms operation	1,500.00
4 Garage expense	650.00
5 Hospital and accidents	1,500.00
6 Extraordinary expenses	1,500.00
7 Taxes	8,300.00
8 Insurance	
9 Miscellaneous	
	\$36,645.00

ACCOUNT 9. DISTRIBUTION BY TONNAGE

	Per Cent	Cost
Blast furnaces	22	\$8,060.00
Open hearth	28	10,260.00
1A mill	15	5,490.00
1B mill	11	4,030.00
1C mill	4	1,465.00
2A mill	8	2,930.00
2B mill	3	1,100.00
3M mill	2	730.00
3M mill	2	740.00
3M mill	1	370.00
4M mill	1	380.00
5M mill	2	730.00
Special product	1	360.00
		\$36,645.00

From Table I we have the following scrap materials that must be disposed of and utilized as far as possible in the plant.

Metallic scrap ingot butts, etc., from open-hearth	6,000 tons
Bloom crops, and crop ends from bars, and rejected materials from the rolling mills (clean scrap)	22,325 tons
Metal loss in slags made in open-hearth	6,800 tons
Metal loss in roll scale, heating-furnace cinder in the rolling mills	2,675 tons

All of the above is not usable, due to contamination with dirty materials, brick bats, etc., but all of the clean scrap is directly usable in the open-hearth, and its recovery may be taken at 100 per cent.

In the case of open-hearth slags, they are not used in the blast furnace as ore, but are employed as a cleaning agent, to add manganese, etc., and their metallic content is thereby recovered.

Cinder and scale are used in the open-hearth replacing ore in the working of the heat, but this use is restricted to the getting of clean materials free from acid content.

In the following I have noted a reuse of 2000 tons of roll scale in the blast furnaces, and of 510 tons of roll scale in the open-hearth division, a total of 2510 tons,

having an average metallic content of 65 per cent iron. This gives a net recovery of 1631 tons of metal out of 2675 tons recorded loss, so that the material efficiency is 60 per cent.

In the recovery of metal from the slags produced in the open-hearth (where 6800 tons are so lost per month in the making of approximately 14,600 tons of open-hearth slag) only selected slag would be recharged in the blast furnaces, and the metal content of such slag would not average over 16 per cent. As 7200 tons of such slag was observed to be recharged, having a metal content of 1150 tons, and as 6800 tons were lost in the open-hearth slags, the material efficiency is about 17 per cent.

In order to arrive at the value of recovery of the waste materials, the following must be considered. The starting point is the blast furnace.

BLAST FURNACES

The value of the raw materials used in the blast furnaces, carries us back still further, to the materials in the ground. To determine the value at the furnace the calculations of Table XI are made.

TABLE XI—NET COST OF RAW MATERIALS AT FURNACE

	Per Ton
Value of the ore in the ground unmined	\$1.300
Average cost of stripping, loading and mining	.350
Transportation to lake ports, 60 miles at \$.005 per ton-mile	.300
Lake transportation, including interest	.260
Loading and unloading steamers	.050
Transportation from lower lake ports to Pittsburgh, 120 miles at 0.005 per ton-mile	.040
Unloading and transferring to stock pile at furnace	.040
Net cost of ore on stock pile	\$2.800
	Per Ton
Value of coking coal in the ground	\$0.60
Average cost of mining, etc.	.19
Beehive coke-oven yield = 66 per cent, or coal cost per ton coke is $(.60 + .19) \div .66$	\$1.197
Cost of coking above cost of coal	.813
Transportation from coke ovens to Pittsburgh	.710
Net cost of coke at furnace plant	\$2.72
	Per Ton
Value of limestone (blast-furnace grade) in the ground	\$0.400
Average cost of mining and loading	.230
Transportation from quarry to Pittsburgh, 100 miles	.500
Net cost of limestone at furnace plant	\$1.030

In as much as the various materials used in the blast furnace, open-hearth, or rolling mills are all converted into materials of value or wastes, the value of flue dust, open-hearth slags, and cinder and scale are unknown at this point. A = real value of flue dust considered as a product, that is its value if iron, flue dust and slag were considered the products of a furnace, the gases being utilized entirely at the furnace plant in the production of steam.

C = real value of open-hearth slag when ingot steel, metallic scrap and all slag are considered as products.

B = real value of roll scale when considered as the product of all rollings together with the finished product.

Using these unknown values we give in Table XII the cost of iron per ton.

TABLE XII—BLAST FURNACES

Material	Tons per Month	Cost per Ton	Material Cost per Month	Cost per Ton, 1500
1 Lake-ores	156,700	\$2.80	\$436,800.00	\$2.82
2 Flue-dust, recharged	3,600	A	3,600 00xA	0.0000A
3 Roll-scale	2,000	B	2,000 00xB	0.0000B
4 Open hearth slags	7,200	C	7,200 00xC	0.0000C
5 Coke	83,000	2.72	225,760.00	2.818
6 Limestone	36,000	1.03	37,080.00	0.463
Products				
1 Pig iron	80,100			
2 Flue dust	8,200			
3 Slag	18,700			

It is obvious that although the flue dust produced was charged for once as ore, that it is an accumulative material, and therefore its value of \$2.80 as ore should be deducted, the cost of flue dust recharged is the cost to make iron + flue dust + slags less \$2.80 per ton. Herein may enter a doubtful economy. In connection with flue dust it may be noted that from the 8200 tons produced there are recharged 3600 tons. This gives a material efficiency of 43 per cent for flue dust.

Writing in form of an equation the cost of materials per ton of iron, we get: Cost material per ton iron = $\$8.733 + 0.045A + 0.025B + 0.090C$. But to arrive at the total cost the cost above the materials must be considered. This averages as stated in Table XIII.

In order to arrive at the net cost above the materials, it is necessary to consider all credits, the laying aside of a fund for relining, and other contingent fund. A blast furnace will last approximately six years on one lining, requiring nearly \$150,000 to completely repair a furnace after making 1,000,000 tons of iron, and 15 cents a ton is taken as representative of a relining contingency and 3 cents a ton as representing general contingency.

TABLE XIII—COST ABOVE MATERIALS. BLAST FURNACE

Item	Cost Average Month	Per Ton Iron
1 Superintendents, clerks, etc.	\$2,330.00	\$0.0291
2 Ore bridges and ore pile	2,225.00	0.0277
3 Stocking and charging	9,000.00	0.1123
4 Blowing	14,000.00	0.1748
5 Hot blast	3,900.00	0.0487
6 Casting	3,500.00	0.0437
7 Material used in repairs	7,500.00	0.0936
8 Refractories used in repairs	3,800.00	0.0474
Total	\$46,255.00	\$0.5773
1 Steam. Boiler horsepower used	\$20,400.00	\$0.2547
2 Water	5,120.00	0.0639
3 Electricity	1,750.00	0.0218
4 Transportation	10,000.00	0.1248
5 Shops. Labor used for repairs	14,115.00	0.1762
6 Laboratory	2,000.00	0.0249
7 Tools and supplies	1,725.00	0.0215
8 General works	8,300.00	0.1036
Grand total	\$109,665.00	\$1.3687
1 Relining contingency	12,000.00	0.1500
2 General contingency fund	2,400.00	0.0300
Total	\$124,065.00	\$1.5487
Credit for steam sold	23,660.00	0.2954
Net cost above materials	\$100,405.00	\$1.2533

The products of value from the blast furnace are iron and flue dust. The latter is of value only when used as ore, and it will be noted from the tables that flue dust is produced at the rate of 8200 tons per month and reused at the rate of 3600 tons, so that this material is accumulative. There are produced in an average month 80,100 tons of iron, and of iron and flue dust and slags 136,400 tons.

Thus we have the total cost of iron per ton

$$= \$8.733 + 0.045A + 0.025B + 0.090C + \$1.2533$$

$$\text{or} = \$9.9863 + 0.045A + 0.025B + 0.090C$$

As there were made 80,100 tons of iron and a total of 136,400 tons of iron, flue dust and slags, which may be considered equally as products, and as $80,100 \div 136,400 = 0.59$, the value of flue dust would be $0.59 \times$ cost of iron — \$2.80 per ton.

$$\text{Hence } A = 0.59 \times (9.9863 + 0.045A + 0.025B + 0.090C) - \$2.80 \text{ per ton.}$$

$$A = \$5.99 + 0.027A + 0.015B + 0.054C = \$2.80,$$

or

$$0.973A = \$3.191 + 0.015B + 0.054C, \text{ hence}$$

$$A = \$3.27 + 0.0154B + 0.055C.$$

$$\text{Thus the cost of iron} = \$9.9863 + 0.045 \times (3.27 +$$

$0.0154B + 0.055C) + 0.025B + 0.090C$. If E = cost of iron per ton, we have

$$E = \$9.9863 + 0.147 + 0.0257B + 0.0925C.$$

B and C cannot be eliminated until more values are determined, so this brings us to the discussion of the open hearth.

From Table I we have the following figures:

Material charged to open hearth, metallic	116,000 tons
Product from the open hearth	103,200 tons
Metallic scrap, i.e. pit and skull scrap, ingot butts, etc.	6,000 tons
Loss, metallic, i.e. metallic content of slags, etc.	8,800 tons

The distribution and values of the materials going into the above are given in Table XIV.

TABLE XIV

Material	Tons per Month	Base Cost per Ton	Cost per Month	Cost per Ton Steel
Hot metal	56,900	E	\$56,900.00E	\$0.551 E
Moulds and stools	1,920	\$25.00	48,000.00	0.4650
Iron scrap	760	20.00	15,200.00	0.1470
Home steel scrap	28,325	D	28,325.00D	0.274 D
Heavy bought scrap	2,335	13.00	32,955.00	0.3194
Light bought scrap	4,440	11.00	48,840.00	0.4734
Fine ore	9,260	2.80	25,928.00	0.2512
Cinder and scale	510	B	510.00B	0.0050B
Dolomite	3,170	2.90	9,193.00	0.0891
Limestone	7,100	1.05	7,455.00	0.0722
Lump ore	2,850	4.50	12,825.00	0.1242
Fluorspar	125	1.80	225.00	0.0022
Hot metal	9,260	E	9,260.00E	0.0807E
Ferromanganese	400	80.00	32,000.00	0.3100
Ferrosilicon	30	40.00	1,200.00	0.0116
Sulphur	10	35.00	350.00	0.0034
Coal. Dry powdered	200	2.00	200.00	0.0019
Aluminium	12	336.00	4,032.00	0.0391
Magnesite	140	25.00	3,500.00	0.0339
Chrome ore	55	16.00	960.00	0.0096
Clay	260	1.35	351.00	0.0034
Loam	450	1.10	495.00	0.0048
Coke	725	2.72	1,972.00	0.0191
Producer gas (coal)	23,920	1.88	44,969.00	0.4357

$$\text{Total} = \$290,680 + 66,160E + 28,325D + 510B.$$

The value of all steel scrap in the plant is signified by D at this point.

The products obtained from the material of Table XIV are:

Ingot and castings	103,200 tons
Ingot butts	1,700 tons
Pit scrap, etc.	4,300 tons
Run-off slag	3,100 tons
Ladle slag	4,100 tons
Normal slag	7,300 tons
Total slags	14,700 tons
Metallic scrap	6,000 tons

Thus the divisor for value of open-hearth slag is 123,900. In order to determine the cost of steel, the cost above materials is figured as given in Table XIVa.

TABLE XIVa—COST ABOVE MATERIALS—OPEN HEARTH

Account	Cost per Month	Per Ton (103,200 Tons)	Per Ton (123,900 Tons)
1 Steam	\$1,775.00	\$0.0172	\$0.0143
2 Water	700.00	0.0068	0.0056
3 Electricity	1,375.00	0.0133	0.0111
4 Transportation	5,000.00	0.0485	0.0401
5 Slags	9,285.00	0.0900	0.0750
6 Laboratory	1,400.00	0.0135	0.0113
7 Material in maintenance	2,500.00	0.0242	0.0202
8 General works	10,260.00	0.0995	0.0829
1 Refractories	2,700.00	0.0261	0.0218
2 Rebuilding	14,450.00	0.1401	0.1168
3 Store supplies	2,500.00	0.0242	0.0202
4 Contingent fund	3,190.00	0.0309	0.0258
1 Superintendents, clerks	2,900.00	0.0281	0.0234
2 Stocking and charging, boxes	11,350.00	0.1101	0.0917
3 Charging furnaces, rollers, etc	4,350.00	0.0422	0.0351
4 Melting and gas tending	17,550.00	0.1702	0.1419
5 Ladle lining	4,400.00	0.0420	0.0356
6 Calcining and alloy house	1,850.00	0.0179	0.0141
7 Mould handling	7,750.00	0.0751	0.0626
8 Scrap and cinder drop or skullcracker	7,000.00	0.0679	0.0565
9 Inspection, shipping and stripping	15,500.00	0.1503	0.1253
Total	\$127,785.00	\$1.2387	\$1.0319

Thus the cost of steel per ton in dollars = $2.8162 + 0.641E + 0.274D + 0.005B + 1.2387$. The cost of open-hearth slag = $2.346 + 0.533E + 0.228D + 0.0041B + 1.0319$.

But E = value found under blast furnaces; hence,

$$C = 3.378 + 0.533 \times (10.133 + 0.0257B$$

$$+ 0.0925C) + 0.228D + 0.0041B,$$

$$C = 3.378 + 5.40 + 0.014B + 0.049C + 0.228D + 0.004B,$$

$$0.951C = 8.778 + 0.018B + 0.228D,$$

$$C = 9.24 + 0.019B + 0.24D$$

= value of open-hearth steel, slag and scrap.

It will be noted in Table I that open-hearth steel is used in the blast furnaces to the extent of 7200 tons per month, and produced at the rate of 14,700 tons per month (a material efficiency of 49 per cent), so that 7500 tons of open-hearth slag have no value. Allowing the open hearth due credit for the slag used in the blast furnaces, the cost of open-hearth steel is: $290,680 + 66,160E + 28,325D + 510B + 127,785 - 7200C$, or the cost per ton of open-hearth steel, which we will call F at this point, is:

$$F = \$4.055 + 0.641E + 0.274D + 0.0050B - 0.069C.$$

In order to arrive at the value of the scrap and scale from the mills, the accounts are tabulated in Tables XV and XVI.

TABLE XV—MILL ACCOUNT

	1A	1B	1C	2A	2B
1 Steam	\$6,500.00	\$8,970.00	\$3,640.00	\$6,760.00	\$780.00
2 Water	150.00	200.00	100.00	180.00	100.00
3 Electricity	500.00	325.00	75.00	225.00	75.00
4 Transportation		1,100.00	500.00	600.00	500.00
5 Shops	3,810.00	2,585.00	1,335.00	2,185.00	660.00
6 Roll shop	1,200.00	3,500.00	1,300.00	1,000.00	750.00
7 Laboratory	50.00	25.00	40.00	25.00	75.00
8 Store rooms	7,400.00	2,700.00	1,300.00	5,850.00	700.00
9 General works	5,490.00	4,030.00	1,465.00	2,930.00	1,100.00
1 Producing labor	4,300.00	9,950.00	3,600.00	7,550.00	2,900.00
Total	\$28,980.00	\$33,385.00	\$13,355.00	\$27,285.00	\$7,640.00
Rollled on (Tons)	66,000	56,800	14,100	36,900	10,500
Scrap	56,800	54,000	13,000	29,200	9,700
Scale, etc.	8,000	2,500	1,000	7,100	750
	1,200	300	100	600	50
Cost of product per ton	\$0.510	\$0.618	\$0.027	\$0.934	\$0.788
Cost of product, scrap and scale per ton	0.439	0.586	0.947	0.739	0.728

TABLE XVI—ROLLING MILLS

Mill Account	1M Mill	2M Mill	3M Mill	4M Mill	5M Mill	Special Product
1 Steam	\$1,940.00	\$1,560.00	\$1,000.00	\$1,080.00	\$3,840.00	\$260.00
2 Water	80.00	80.00	40.00	40.00	120.00	
3 Electricity	500.00	500.00	200.00	300.00	1,000.00	
4 Transportation	300.00	300.00	200.00	200.00	400.00	200.00
5 Shops	655.00	770.00	170.00	185.00	825.00	
6 Roll	300.00	600.00	300.00	300.00	1,500.00	
7 Laboratory	75.00	75.00	75.00	75.00	75.00	
8 Store rooms	750.00	850.00	400.00	500.00	1,250.00	
9 General works	730.00	740.00	370.00	380.00	730.00	360.00
1 Producing labor	9,600.00	9,900.00	6,075.00	7,200.00	8,935.00	1,450.00
2 Fuel	965.00	1,000.00	185.00	335.00	1,125.00	
Total	\$15,995.00	\$16,275.00	\$9,015.00	\$10,595.00	\$19,800.00	\$2,270.00
Rollled on (Tons)	8,000	9,000	1,550	2,800	8,500	2,200
Scrap	650	900	125	250	1,000	50
Scale	150	100	25	50	100	
Product	7,200	8,000	1,400	2,500	7,400	2,150
Cost per ton product	\$2.207	\$2.034	\$6.439	\$4.238	\$2.675	\$1.056
Cost per ton product, scrap and scale	\$1.987	\$1.808	\$5.816	\$3.784	\$2.212	\$1.031

At this point it is necessary to follow the steel through its various rerollings.

The steel rolled in 1A Mill is rerolled in 1B Mill, and part of the product is then rerolled in 1C Mill. Product from 1B Mill is rerolled in 1M Mill and 2M Mill, and part of the product from 1C Mill is rerolled in 3M Mill and 4M Mill. Part of the product from 2A Mill is rerolled in 2B and part in 5M Mill. The special prod-

ucts are assumed to take their raw material from 2M Mill. Accordingly the values are tabulated in Table XVI, the scrap being figured direct, and remelted in the open hearth, and its value D being directly determined. In the case of roll scale, a metallic content of 65 per cent average is taken, the figures tabulated, being, however, metallic contents and not figured as the oxide.

TABLE XVII—VALUES OF SCRAP AND SCALE

Part of Mill	Scrap, Tons	Roll Scale	Value per Ton	Total Cost
Openhearth	6,000		$\$9.24 + 0.019B + 0.24D$	$1440D + 114B + \$55,425.00$
1A mill	8,000	1,200	$F + 0.439$	$9200F + 1,080D$
1B mill	2,500	300	$F + 0.439 + 0.586$	$2500F + 2,870.00$
1C mill	1,000	100	$F + 0.439 + 0.586 + 0.947$	$1100F + 2,189.00$
2A mill	7,100	600	$F + 0.739$	$7700F + 5,691.00$
2B mill	750	50	$F + 0.739 + 0.728$	$800F + 1,173.50$
1M mill	650	50	$F + 0.439 + 0.586 + 1.987$	$800F + 2,409.50$
2M mill	900	100	$F + 0.439 + 0.586 + 1.808$	$1000F + 2,833.00$
3M mill	125	25	$F + 0.439 + 0.586 + 0.947 + 5.816$	$150F + 1,192.50$
4M mill	250	50	$F + 0.439 + 0.586 + 0.947 + 3.784$	$300F + 1,726.70$
5M mill	1,000	100	$F + 0.739 + 2.212$	$1100F + 3,246.00$
Special product	50		$F + 0.439 + 0.586 + 1.808 + 1.031$	$50F + 193.50$
Total	28,325	2,675		$25,000F + 1,440D + 114B + \$2,915.50$

Table XVII gives the values of scrap and scale and from it we get

$$31,000D = 25,000F + 1,440D + 114B + 82,943.50$$

$$D = 2.676 + 0.806F + 0.046D + 0.0037B$$

$$D = 2.812 + 0.847F \text{ (since } B = 0.65D)$$

We are now able to give Table XVIII, which gives representative real costs as they would be in the steel plant.

It will be seen from Table XVIII that flue dust costs really \$4.146 to make and many plants are spending one more dollar per ton to sinter this material, which brings the cost up to \$5.146 per ton. This material is expected to replace ore at \$2.80 a ton. It is quite apparent that this is doubtful economy.

TABLE XVIII—PRIME COST OF MATERIALS DETERMINED FROM THE FOREGOING

Material	Cost per Ton	Equation	Prime Cost
Flue dust	A	$3.27 + 0.0154B + 0.055C$	\$4.146
Pig iron	B	$10.133 + 0.0237B + 0.0925C$	12.013
Open hearth slag	C	$2.346 + 0.533E + 0.228D + 0.0041B$	14.841
Open hearth steel	F	$4.055 + 0.641E + 0.274D + 0.005B - 0.069C$	15.371
Average steel scrap	D	$2.812 + 0.847F$	9.991
Average roll scale	B	$0.65D$	4.083

TIME STUDY FOR VARIOUS WORKING UNITS

A blast furnace has a life of approximately 1,000,000 tons on one lining, and accordingly is idle at the end of a period of six years. In order to completely repair a furnace after such a run, a period of approximately four and one-half months is required. Thus the time lost for rebuilding purposes is 5.88 per cent of the total time from blowing-in to blowing-in. In a plant involving six furnaces there would be lost a total of twenty-seven furnace-months for the relining in a period of six years so that this non-productive period is of material consideration, or 6.2 per cent of the working time.

An open-hearth furnace has a working period of approximately 400 heats, and approximately one month's time is consumed each year for rebuilding, so that this rebuilding period represents 8.5 per cent of the time from run to run, although including the time required for replacement of one roof.

The rolling mills are all subject to mechanical repairs, not being affected chemically as the blast and open-hearth furnaces. The heating furnaces in conjunction with a rolling mill are subject to the wearing out due to chemical changes, and the pit furnaces as operated, representing eleven units, are subject to one

pit down for repairs continually, leaving ten in operating conditions, so that to these heating furnaces 9 per cent of the time is consumed in rebuilding.

In connection with all of the units unavoidable delays are present, such as tapping time, *i.e.*, when the furnace is not being used due to blast off, mechanical delays affecting all units, roll change time during the time when mill should be working, etc., all of which should be subject to investigation. In Table XIX there is also included the operation period of a thirty-day month, wherein the blast furnaces are in continuous operation, the other units being allowed four Sundays or the equivalent off per month.

TABLE XIX—PERIOD OF 30-DAY MONTH

Unit	Number	Rebuilding, per Cent	Perfect Time per Unit, Hours	Perfect Time Gross, Hours	Unavoidable Delays, Hours
Blast furnaces	6	6.2	720	4,320	72
Open hearth	32	8.5	624	19,968	192
Strippers	2		624	1,248	
Soaking pits	11	9.0	624	6,864	
1A mill	1		624	624	26
1B mill	1		624	624	78
1C mill	1		624	624	13
2A mill	1		624	624	54
2B mill	1		624	624	13
1M mill	1		624	624	67
2M mill	1		624	624	91
3M mill	1		624	624	39
4M mill	1		624	624	67
5M mill	1		624	624	104

The following time studies are averages of observed conditions and are representative:

TIME STUDY FOR BLAST FURNACES

Number of Units	Operation	Lost Time Rebuilding, per Cent	Lost Time Unavoidable, per Cent	Working Efficiency, per Cent
6	Continuous	6.2	1.66	92.14

TIME STUDY FOR OPEN HEARTH

As noted in Table XIX, the lost time due to rebuilding is 8.5 per cent of the working time, so that out of a plant of thirty-two furnaces there are twenty-nine furnaces in continuous operation, giving some 7950 ingots a week, and making some 317 heats of twenty-five ingots each. The figures in time are in parts of an hour.

TABLE XX

	Per Month	Per Cent	Hours per Heat
Units	32	100.0	
Off-rebuilding	3	8.5	
Operating	29	91.5	
Hours	1,373		
Continuous—32 units	19,968		
Actual—29 units	18,080	100.00	
Rebuilding	1,888		
Unavoidable delays	192	1.06	
Net working time for 29 units	17,888	98.94	
Charging	3,199		2.33
Melting	9,721		7.08
Tapping	341		.25
Capacity	343		.25

Total capacity is 13,697 hours

Total of operations of 29 units per month	48,080 hours	Per Cent
Total lost and chargeable to operation	192 hours	1.06
Actual time consumed in the blast furnaces	47,888 hours	75.26
From the average efficiency of the open-hearth as run—29 units	75.00	
At the average efficiency of the plant—32 furnaces	68.00	

STRIPPERS

The plant contained two strippers, and the following are noted performance:

	Per Month Hours	Per Heat Hours	Per Cent.
Transfer from poring stand to strippers	220	0.16	
Stripping	563	0.41	
Heats stripped	1373	1	
Hours in month	624		

Number of heats stripped if the operation were continuous = 1522 by one machine, or 3044 for the pair of strippers.
Working efficiency of two strippers = $1373 \div 3044 = 45.1$ per cent.

SOAKING PITS

A soaking pit of four holes will hold approximately one heat of twenty-five ingots, and out of a plant of eleven pits, one set will be off for rebuilding, so that ten pits are in continuous operation.

	Per Heat, Hours
Second transfer from the strippers to pits	0.08
Charging in Pits	0.39
Soaking	1.02
Drawing pits	0.42
Bottom making	0.20

Total time cycle from full to empty pits, excluding the transfer, is approximately two hours per heat.

Thus one set of pits will accommodate twelve heats per day in continuous operation. And ten sets of pits will accommodate 120 heats per day.

The actual average performance of ten pits for the ingots from the twenty-nine open-hearth furnaces as operated was at the noted tabulated rate of fifty-three heats per day of 24 hours.

Working efficiency = $\frac{\text{Actual accommodation}}{\text{Maximum capacity}} = \frac{53}{120} = 44\%$

ROLLING MILLS

The following are average results such as may be expected from the usual rolling mill plant:

	Per Heat, Hour	Tons Rolled per Hour
Transfer from the pits to the rolling mill table	0.20	
Rolling in 1A mill to bloom	0.48	1.52
In bloom shears, cropping and making 2 blooms	0.28	

The average heat is taken as 73 tons and of 25 ingots per heat, and as the slowest operation is the tonnage determining, the capacity is the time of this operation in hours divided into the tonnage for that time.

From Table XIX it will be noted that such a mill operating for one month has 26 hours down due to unavoidable delays, such as roll change, mechanical breakdown, etc., coming at extraordinary time, which leaves 598 hours for working, out of a possible 624 for perfect time. Ordinarily roll changes on such a mill should take place on the Sunday time.

Thus the actual working hours—598 times 152 tons = 90,000 tons—is the maximum capacity for continuous operation.

The actual average tonnage of such a mill is noted as 66,000 tons.

Thus the working efficiency of 1A Mill = 73%.

1B MILL

The two blooms from 1A Mill delivered to the rougher of 1B Mill are rolled simultaneously, delivered to 1 Stand, where one is rolled into billet form and one into the rough billet for shape. Thus 1 Stand has the same capacity as the rougher. On account of the lengthening out of the rolled material from pass to pass, the capacity of such a mill is limited to the time of the longest pass.

From 1 Stand there would be delivered one billet finished to 4" x 4" section, and the rough shaped for

the other stands of 1B Mill. The 4x4 section can either become commercial billets being sheared to salable length, or the raw material for 1C Mill. Thus the following time study comes in:

TABLE XXI

Part	Time in Hours per Heat of 73 Tons, 25 Ingots	Tons Rolled On per Hour (By Consuming Operation)
Two blooms in rougher.		
Rougher	0.47	
1 stand	0.50	146
	(2 pieces)	
2 pass	0.125	
3 pass	0.175	
4 pass	0.250	
5 pass	0.400	
6 pass	0.550	132
Billet shears for part product No.		
1 stand	0.825	88
1C mill, complete	0.825	88
Sawing product from No. 6 pass	0.250	

TIME STUDY OF 1B AND C MILLS

Since all of the product passes through the rougher and 1 Stand it is evident that there must be an alteration between the 4x4 shears and the 1C Mill, for maximum production, of all three considerations, so that one billet would go into 4x4 while rolling for the 1B Mill, and the next following billet go to the 1C Mill.

From the above it follows that as there are 624 possible hours in a month, and from Table XIX 78 hours are deducted for unavoidable delays, the remaining 546 are tonnage rolling hours, which at 132 tons per hour for the 1B Mill slowest pass gives 72,072 tons as the maximum capacity.

Thus capacity = 72,000 tons, while the actual performance is 56,800 tons, hence working efficiency of 1B Mill = 78%.

1C Mill, working 624 less 13 hours for unavoidable delay, gives 611 tonnage rolling time, which at 88 tons per hour is 53,768 tons per month.

The actual material rolled on for such a mill averages 14,100 tons, so that the working efficiency of such a mill is 26%.

As worked alternately giving product to the 1C Mill, the 1B Mill capacity is limited to the time of pass 1 only, which rolls two blooms down at the same time, having a capacity of 146 tons per hour. With tonnage rolling time of 546 hours, this capacity is 79,716 tons per month.

Thus the working efficiency at maximum capacity = 73%.

TIME STUDY FOR 2A AND B MILLS

The performance of 2A Mill will be different from 1A Mill on account of the different product desired, involving greater reduction by the mill from ingot to finished bloom or slab. The following table is representative of time consumed in the operations. Time in hours:

	Per Heat	Tons Rolled on per Hour
Transfer of ingot from soaking pits to rolling mill table	0.200	80
Rolling in 2A mill to bloom or slab	0.910	
Transfer to shears	0.625	
Shearing, average	0.750	

The working time of 2A Mill averaged as follows:

	Hours
Total available hours per month	624
Unavoidable delays	54
Net rolling time	570

570 hours' rolling time at 80 tons per hour, for the time-consuming operation in the rolling mill, is 45,600 tons per month.

The average performance of the mill is 36,900 tons rolled on per month.

Hence the working efficiency of 2A Mill = $36,900 \div 45,600 = 80\%$.

Part of the product of 2A Mill is rerolled in 2B Mill into small billets.

	Per Heat	Time per Hour
Transfer from rolling mill to 1 stand of 2B mill	0.650	
Time to roll in 2B mill, rolling on a bloom sheared into two pieces	1.000	7
Transfer from 2B mill to hot beds	0.400	

The time-consuming operation rolled at the rate of 73 tons per hour, and the total available rolling time for such a mill is 624 hours, less 13 hours for roll change, repairs of mechanical defects, etc., giving a net rolling time of 611 hours. Thus the maximum capacity of such a mill is 44,600 tons per month.

The actual performance for the mill averages 10,500 tons rolled on per month.

Hence the working efficiency is $\frac{10,500}{44,600} = 23.5\%$.

All of the products of the above mills are allowed to cool, and then transported to the merchant mills. The heat lost would be valuable if the products could be utilized at once in the bar mill furnaces, and proper placement of such mills could utilize such heat efficiently.

TIME STUDY OF MILLS, 1M TO 5M

Table XXII gives the working efficiency of the bar mills.

The time consuming pass or operation is taken as guide to maximum capacity.

TABLE XXII—TIME STUDY OF THE BAR MILLS

Mills	1M Mill	2M Mill	3M Mill	4M Mill	5M Mill
Heating furnaces, minutes	40	40	30	40	40
Time determining pass, in seconds	35	80	36	80	45
Average weight of billet, lb.	300	1,200	80	220	800
Capacity of slowest pass in tons per hour	16.6	22.7	3.57	5.8	28.6
Time for 1 ton, hours	0.60	0.11	0.280	0.171	0.035
Total hours in month	624	624	624	624	624
Unavoidable delay	66	91	39	97	194
Net rolling time	558	533	585	527	430
Maximum tonnage per month	9,230	12,100	2,088	3,230	14,800
Average actual tonnage per month	8,000	9,000	1,550	2,800	8,000
Working efficiency	86%	74%	74%	86%	57%

The diversity of product rolled on such mills naturally retards the product and the obtaining of maximum capacity of material rolled on. A gage to this diversity would be the amount of roll change that such mills are subject to.

In order to appreciate what the attainment of more perfect working efficiency would mean, the two tables, XXIII and XXIV, attached for a summary of the foregoing, should be given due consideration.

These figures of Tables XXIII and XXIV give an idea as to what betterment of mechanical working and organization would do toward economy in the rolling mill.

The valuations of product are not market values, as the cost figures are not those of product but of the amount of material handled, rolled on, etc., and thus are prime costs representing the handling of all ma-

TABLE XXIII—SUMMARY

Part of Plant	Working Efficiency	Prime Cost per Ton Rolled On	Tons Material per Month	Cost of Handling	Cost as it at 100 Per Cent Efficiency	Difference
Blast furnaces	92.14	\$12,019	80,100	\$962,200.00	\$1,044,000.00	\$181,800.00
Open hearth	68.00	15,371	103,200	1,586,200.00	2,333,000.00	746,800.00
Strippers	45.10	0.016	103,200	1,631.00	3,669.00	2,038.00
Soaking pits	44.00	0.095	102,900	9,775.00	22,217.00	12,442.00
1A mill	73.00	0.439	66,000	28,975.00	39,690.00	10,715.00
1B mill	78.00	0.586	56,800	33,285.00	42,675.00	9,390.00
1C mill	26.00	0.947	14,100	13,350.00	51,340.00	37,990.00
2A mill	80.00	0.739	36,900	27,270.00	34,085.00	6,815.00
2B mill	23.50	0.728	10,500	7,645.00	32,560.00	24,915.00
1M mill	86.00	1.987	8,000	15,895.00	18,480.00	2,585.00
2M mill	74.00	1.808	9,000	16,270.00	21,989.00	5,719.00
3M mill	74.20	5.816	1,650	9,015.00	12,180.00	3,165.00
4M mill	86.00	3.784	2,800	7,400.00	8,605.00	1,205.00
5M mill	57.00	2.212	8,500	38,430.00	67,420.00	28,990.00
Special products		1.031	2,200	2,268.00		

Maximum possible saving per month

TABLE XXIV—THE MATERIAL EFFICIENCY OF SOME PRODUCTS

Material	Where Made	Amount per Month, Tons	Recharged, Tons	Accumulative, Tons	Efficiency of Recovery, Per Cent	Prime Cost per Ton	Prime Value of Materials as is the Custom to Utilize	Prime Value of the Materials Discarded
Flue dust	Blast furnaces	8,200	3,600	4,600	44	\$4.146	\$14,925.00	\$19,071.00
Slag	Blast furnaces	48,100	None	48,100		6.946		334,102.00
Metal scrap	Open hearth	6,900	6,900		100		See metal scrap	
Slag	Open hearth	14,700	7,200	7,500	49	14.841	106,855.00	111,307.00
Metallic loss	Open hearth	6,800	1,080	5,720	16	14.841	16,028.00	85,890.00
All metal scrap in plant	All departments	28,325	28,325	None	100	9.991	283,250.00	
Roll scale metal content	All departments	2,675	1,631	1,044	60			
Roll scale	All departments	4,011	2,510	1,501	60	4.085	10,253.00	6,131.00

terials. Any betterment would naturally increase the profit, due to greater credits and less net cost of the products salable. Some of the figures for single departments warrant the so-called research action, but the problems are more of a kind to be solved by a planning department than by chemical or mechanical experts. In spite of the relatively great material efficiency of the average steel plant, the fact that much time is lost and the working efficiency of some departments is low, makes the problem one for a staff of men, and not the work of the single manager or man directly in charge of a single producing unit. Each and every department's close co-operation is essential for the approach to 100 per cent working efficiency. This calls for planning, routing and grouping of work, even though the materials handled run into the thousands of tons daily.

In all of the above calculations it will be noted that the figures for mill rolling performance relate to the material rolled on and not the product obtained. This method gives a definite means of obtaining capacity, while it would not be so if the product obtainable from such mills were taken as the basis. Product in turn will be determined by the quality of the material rolled on, the skill of the operatives, etc.

It is the practice in rolling steel to compensate many employees by piece work or tonnage production, but in order to obtain maximum production it is quite obvious that the working efficiency is a figure of great importance, and this should not be kept hidden. With scarcity of labor becoming a paramount factor in all industries, the working efficiency of all mechanical appliances, from machine tools to blast furnaces, is something to be reckoned with; and it seems that there is a profitable field of endeavor in the steel industry for the planning room and for planning systems such as practised in the production of mechanical and electrical finished products, taking this function away from the man-driving managers so often in steel plants.

The Taylor Instrument Companies, Rochester, N. Y., are building a new up-to-date power plant containing automatic stokers, electric coal and ash handling equipment; coal, water and steam weighing and measuring instruments.

Large Increase in By-Products from Coke Ovens

Statistics as to the recovery of by-products from coke ovens in the United States in 1915, contained in a report recently issued by the Geological Survey show the tremendous growth of the by-product coke industry up to the end of 1915. The value of the by-products in 1915 was nearly \$80,000,000 as compared with a previous high value of \$17,500,000 in 1914. The greatest increase was in benzol products whose value rose from less than \$1,000,000 in 1914 to more than \$7,760,000 in 1915. Benzol has been recovered in this country from coke-oven gas for a number of years but prior to 1915 the market was small and the price low. The following table shows the amounts and value of the various products recovered. The increase in by-product coking has been very great since the beginning of this year and production is far in excess of the 1915 figures.

BY-PRODUCTS OBTAINED FROM COKE-OVEN OPERATIONS IN 1915

Product	Quantity	Value	Average Value
Tar obtained and sold, gallons	138,414,601	\$3,568,384	\$0.026
Ammonia obtained and sold	199,900,487	5,648,958	.028
Sulphate, pounds	10,626,612	1,240,473	.117
Liquor, gallons	30,002,196	2,978,044	.099
Anhydrous, pounds	23,667,614		
Gas produced, M cubic feet	17,196,426	3,083,311	.179
Surplus gas sold or used	27,590,624	3,158,129	.114
Illuminating, M cubic feet	39,568,864	2,383,459	.060
Domestic fuel, M cubic feet			
Industrial fuel, M cubic feet			
Benzol products:			
Crude light oils, gallons	13,082,678	4,304,281	.33
Secondary light oils, gallons	182,039	28,731	.16
Benzol, gallons	2,616,483	1,428,323	.568
Toluol, gallons	623,506	1,529,803	2.46
Solvent naphtha, gallons	196,151	46,233	.24
Naphthaline, pounds	465,866	46,959	.10
Other products		379,491	
Coke, short tons	14,072,895	\$29,824,579	
		48,568,325	3.45
		\$78,382,904	

* Includes breeze, retort carbon, domestic coke and coke dust, and aniline oil.

These by-products were obtained by the carbonization of 19,500,000 tons of coal, from which 14,000,000 tons of coke was obtained.

Mechanical Engineering of a Synthetic Phenol Plant

BY FREDERICK POPE

The chemistry of synthetic phenol is so generally understood that I will not go into it.

Our general plan is to sulfonate benzol, make the calcium salt, convert that to the sodium salt and fuse with caustic soda, decomposing the sodium phenolate with a mineral acid and refining the phenol by distillation.

STORAGE OF BENZOL AND ACID

The storage tank for benzol must be of ample capacity, closed, of iron and located in a building that can be heated in winter. The building should be well ventilated and electric light bulbs enclosed in airtight or marine fixtures. The benzol should be pumped to the measuring tanks. If the pump is a steam pump, it should be built with a long spacer separating the water end from the steam end. It is a good plan to run this benzol pump with compressed air. It is unwise to handle the benzol with a monteju unless special precautions are taken. This benzol house should be so located as to avoid exposure of this building to fire or sparks caused by passing engines, etc.

Sulphuric acid storage should be of ample capacity. The tanks should be located in a building that can be heated during the winter months. Sulphuric acid can be handled from the storage building to the measuring tanks with a monteju. When convenient, I prefer to force the acid from the storage tanks to the monteju with compressed air, although it is a good practice to draw the acid from the bottom of the tank through an opening in the bottom of the acid tank. This, however, is open to the objection that it is difficult to replace a valve unless the tank is emptied of acid. The building must be well ventilated and the floor provided with drains connected with a sewer so that the floor may be washed off. If possible, both the benzol and sulphuric tanks should be below the track level to allow filling of the tanks by gravity.

MEASURING TANKS

The measuring tanks should be of ample capacity. The sulphuric acid and benzol may be measured by volume, but I very much prefer to mount the measuring tanks on scales, connecting the scales with the pipes to the sulfonating kettle through a spring coil so that the acid or benzol may be weighed. This not only insures accuracy in the process, which may or may not be important, but is economical, which is a consideration with high-priced benzol and sulphuric acid.

There should be a measuring tank for benzol and one for sulphuric acid; these tanks should be vented through the roof. The sulphuric acid tank should be provided with a seal which will dry the air entering the tank.

My general plan is to arrange the tanks so that they shall be filled to an approximate amount; then the scales are adjusted with weights until they balance. One of these weights should represent the exact weight of the charge desired. After the scales have balanced, this weight should be removed and the acid or benzol allowed to run into the sulfonating kettle until the scales balance again and then the supply promptly shut off.

I arrange this by having an indicator from the scale directly in front of the valve controlling the flow from the measuring tank to the sulfonating kettle, having separate inlets for sulphuric acid and benzol, thus enabling the operator to control the supply promptly.

Each sulfonating kettle is equipped with a reflux condenser of the single-pipe type; in form it should be a coil of pipe contained in a tank, which tank is pro-

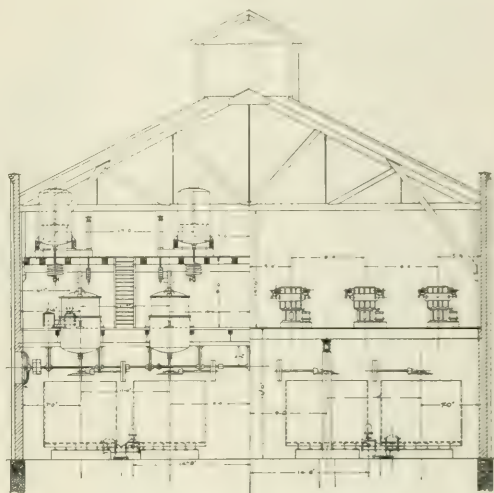
vided with a water inlet and outlet, the condensing coil is extended at the bottom to connect with the sulfonating kettle and at the top to extend through the roof, the coil so arranged that vapors condensed therein will drain back into the sulfonating kettle.

This coil should be of ample area to give free vent from the sulfonating kettle through the roof out of the building and ample surface to condense the maximum amount of vapor it might receive.

SULFONATING KETTLE

The sulfonating kettle is made of cast iron. Some of the special irons made by various manufacturers have advantages over ordinary cast iron.

The ratio of depth to the diameter must be carefully considered, the depth being somewhat greater than the diameter. The shape of the bottom must also be care-



CROSS-SECTION OF BENZOL BUILDING

fully considered on account of the relation it has to the agitator.

The agitator should be of the propeller type without a bearing at the bottom. I prefer the propeller type of agitator with a single propeller working in a tunnel. The shaft should be of ample size and the propeller shaft and driving pulley carefully balanced.

I prefer to drive the agitator with a belt directly to a pulley on the agitator shaft rather than through bevel gears as is often done. This can be arranged by using quarter turned belt.

The kettle should be provided with a manhole of ample size in the cover and with a thermometer tube extending nearly to the bottom. The thermometer should be a recording thermometer with a flexible connection between the kettle and the instrument. The space between the thermometer bulb and the inside of the thermometer pipe should be filled with precipitated copper or with a mixture of graphite and precipitated copper.

The kettles are steam-jacketed. The steam jacket need not extend more than two-thirds of the height of the kettle. The steam jacket should be provided with a safety valve.

The steam to the jacket of the kettle should enter

through a reducing valve, or a much better arrangement is to use low-pressure exhaust steam.

Cold water should be piped to jacket to cool off accidentally overheated charge.

The steam jacket is connected at the bottom through a pipe to a steam trap. Each sulfonating kettle should have its own steam trap.

The sulfonating kettle may be discharged by using compressed air into the top of the kettle and blowing the charge out through a pipe extending to the bottom, although a much better arrangement, and one that should be used whenever possible, is to have the discharge pipe from the bottom of the kettle, this will pass through a stuffing box in the kettle jacket and is provided with a valve as close as possible to the kettle.

LIME MIXING TANKS

Lime mixing tanks must be of ample capacity. The lime mixers should be iron tanks provided with a powerful stirring device and equipped with an iron basket made in the shape of a segment or a circle, the short dimension of which is $\frac{1}{4}$ the depth of the tank. The depth of the baskets is about $\frac{1}{4}$ the depth of the tank; they may be made of thin plate punched full of small holes or of wire mesh.

The mixer must be piped to receive either hot or cold water and steam. Steam is introduced near the bottom of the tank through a circulating jet.

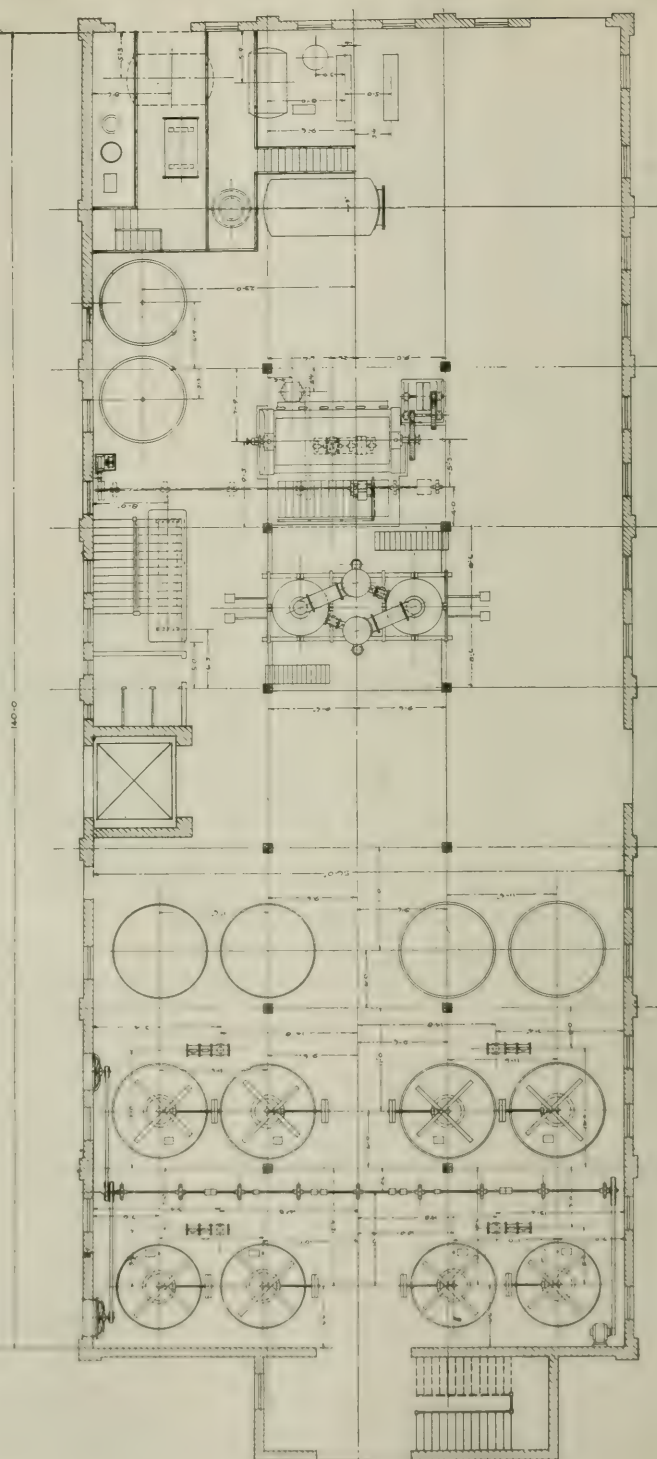
The tank should be set at such an elevation as to allow the milk of lime to flow to the lime mixing tub by gravity. Pipe connection between the lime mixing tanks and the liming tubs should be as short and as straight as possible and so arranged that the pipes will drain and may be blown out if necessary.

LIMING TUBS

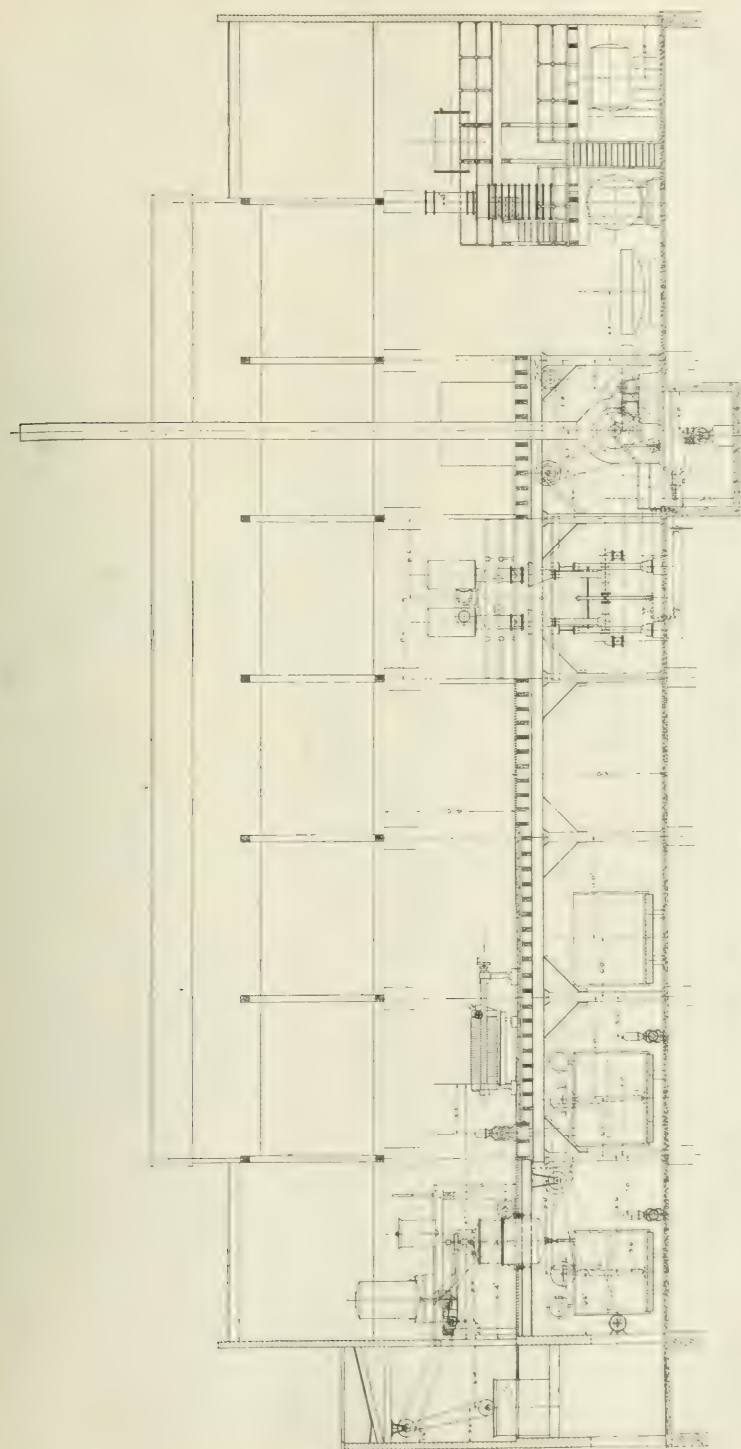
Liming tubs, one for each sulfonating kettle, are made of iron or yellow pine, equipped with a stirring device. The stirring device should be of iron, preferably cast iron.

These tanks are to be located near the sulfonating kettles, piped with cold water and equipped with lead coils on the inside through which cooling water may be circulated.

The liming tubs must be



BENZOL BUILDING—FIRST FLOOR PLAN



LONGITUDINAL SECTION OF BENZOL BUILDING, SHOWING APPARATUS AND MACHINERY

equipped with steam supply to heat the contents of the tub. Steam should be introduced near the bottom, preferably through a circulating heater jet. The outlet should be as close as possible to the bottom and on the side of the tank.

Either a pump or montejus may be used to supply the filter presses. If a montejus is used, it must be below the tanks so that it can be filled by gravity. If a pump is used, it should be supplied with bronze rods. The connection between the pump or montejus and the liming tubs and between the pump or montejus and filter press should be of ample area and as short and straight as possible, provided with means for blowing out. There should be at least one pump or montejus for each two liming tubs.

LIME FILTER PRESSES

The filter press, which should be the wash type, may be either plate and frame or one of the patented type. I prefer the plain plate-and-frame presses, the frames being designed for a 2-inch thick cake.

There should be ample filtering capacity. The filter presses should be located above the soda tubs.

The best type of filter press for this work is the side inlet type, which does not require holes in the plates or cloths but in which the liquid to be filtered enters through holes in the side lugs and the wash water through holes in the side lugs on the other side.

The press is piped so that it may be washed with either hot or cold water and blown with either air or steam. The discharge from the press is arranged so that it may be discharged to the sewer or to the soda tubs.

SODA TUBS

Soda tubs, one for each sulfonating kettle, are made of iron or yellow pine, equipped with a stirring device. The stirring device should be of iron, preferably cast iron.

These tanks are located on the same level with the liming tubs below the filter presses. They should be equipped with indirect heating coils as well as means for heating with live steam similar to the liming tub. The outlet should be as close to the bottom as possible on the side of the tank.

Either a pump or montejus may be used to supply the filter presses. If a montejus is used, it must be below the tanks so that it can be filled by gravity. If a pump is used, it should be supplied with bronze rods.

The connection between the pump or montejus and the liming tubs and between the pump or montejus and the filter press should be of ample area as short and straight as possible, provided with means for blowing out. There should be at least one pump or montejus for each two soda tanks.

SODA FILTER PRESSES

These are arranged the same as the lime filter presses and all remarks about the filter presses apply here, except that the filter presses are arranged to discharge into either sewer or storage tanks.

The cake from both sets of filter presses is caught in a car mounted on wheels, arranged so that it can be dumped through a chute into a car to receive the cake outside.

It is possible, and in some cases desirable, to have a hopper below the filter press extending the length of the plates and frames so that the cake may be discharged through this hopper into a cart or car below to take it away. Either method admits of economic handling of the filter cake.

STORAGE TUBS

Storage tubs to hold the weak sodium benzol sulfonating solution may be of iron or yellow pine; I prefer to use yellow pine. They must be of ample capacity, large enough to hold at least three days' production of weak liquor.

EVAPORATORS

In a large plant, it is advisable to use a multiple-effect evaporator although in a small plant it is better to use a single effect.

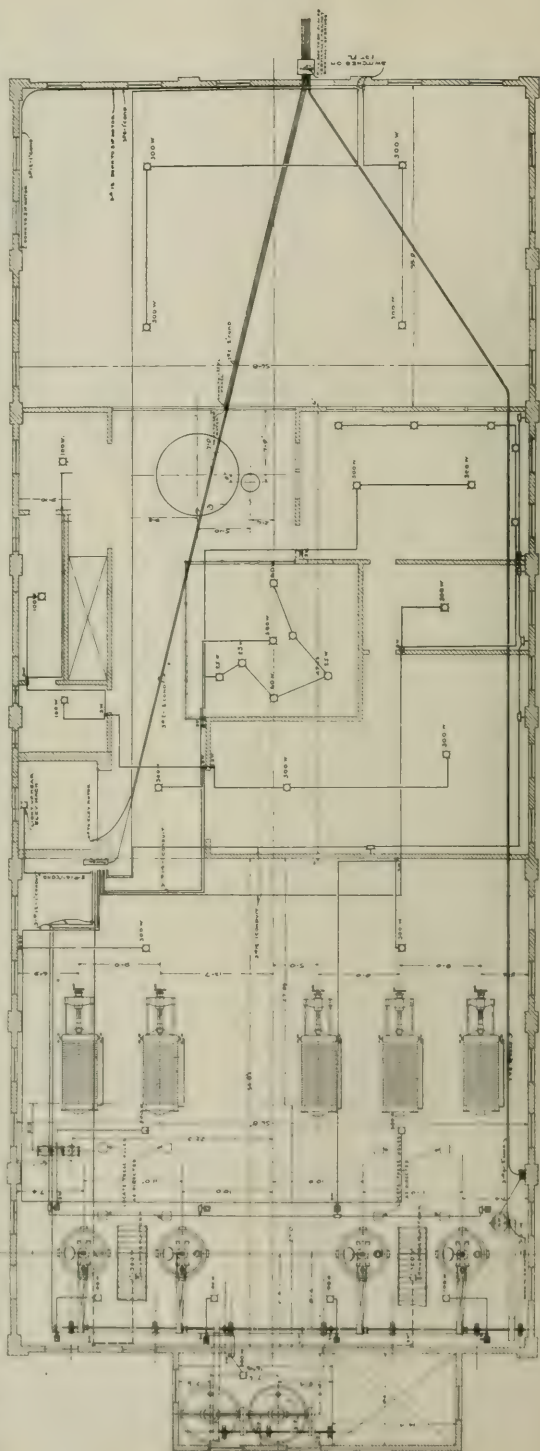
There has been considerable mystery made about evaporators for sodium benzol sulfonate. Any standard machine does the work provided the construction of the machine allows a free and easy circulation of the boiling liquor. Obstructed circulation of liquor will cause the evaporator to scale and lose its efficiency.

A vertical tube, vertical-shell basket-type of evaporator with a splash plate over the basket is the best type to use.

It is a good plan to make the bottom head hinged so that it may swing clear, giving easy access to the tubes for cleaning. However, this is really unnecessary, although desirable, if ample manholes are provided, as the evaporator should run four months without being cleaned.

The shell must be provided with peep holes, gage glasses, etc.

Between each effect and between the final effect, and the air pump, catch-alls or separators must be used to catch any entrained liquid going over with the vapor and so piped that this entrained liquid will be led back to the body of the evaporator.



BENZOL BUILDING—SECOND FLOOR PLAN

The vacuum pump is of the ordinary type of wet vacuum pump and condenser.

The condensed water pump is the ordinary stock type.

The heavy liquor pump is of the Magma pump type; the standard stock patterns of the various pump companies are suitable. Steam pumps are preferable as they are less noisy in operation. It is wise to provide a spare Magma pump, and in a large plant a spare vacuum pump.

A very good arrangement, and one which can be easily made in the case of a double-effect evaporator, is to so pipe the apparatus so that it can be run as a double effect or either shell as a single effect.

In case of a triple-effect evaporator, it is easy to arrange the piping so that it may be run as a triple effect or with any two baskets as a double effect. The object of this is to permit cutting out of any shell for cleaning or repairs without affecting the capacity of the plant.

The heating surface should be designed to evaporate the required amount with 15 lb. pressure as the evaporator should be piped to the 15-lb. line, of which I will speak later.

The heavy liquor from the evaporator is discharged by a Magma pump to the heavy liquor storage tank which is a closed iron tank well covered with insulating material, equipped with steam-heating coils in the bottom and of sufficient capacity to hold three days' output.

The pipe from the Magma pump to the storage tank should be as short and as straight as possible without pockets and arranged so that it may be blown out. The heavy liquor storage tank is located over the drier so that it will feed to the drier by gravity.

SALT DRIER

There are a number of methods of drying the heavy liquor. It may be accomplished with a mechanical drier of the drum or disc type or by drying in open pans.

It is possible, of course, to crystallize the benzol sulphate out of the solution, but that method is open to many objections and I will eliminate it from this discussion.

The best means that I know of is to use a rotary drum drier. It is economical of labor, delivers crystals of a suitable size for fusion, and above all, produces a salt containing a uniform amount of moisture. This is important, for, unless the percentage of moisture in the salt going to the fusion kettles is known, the amount of actual salt used cannot be known.

SALT CONVEYING SYSTEM

The salt from the drum drier discharges over an apron into a screw conveyor parallel to the drum. This screw conveyor discharges into a bucket and belt elevator which discharges the salt on to a conveyor of either screw or belt type and carries it into the fusion building where it discharges into a bin of ample capacity. The salt is drawn from the bottom of the bin into galvanized iron cans—ordinary ash cans being used for this purpose, each can holding 100 lb. salt.

All the foregoing apparatus should be in one building in which there is not any fire or flame of any sort, except the salt storage bin, which is in a second building entirely separate from the first and a short distance from it. This second building will contain the apparatus next described.

FUSION KETTLES

Fusion kettles are cast-iron kettles. The special mixtures of various manufacturers have some advantage over the ordinary cast iron. The kettles are of elongated hemispherical shape and set in a steel shell lined with brick with a layer of asbestos between the brick

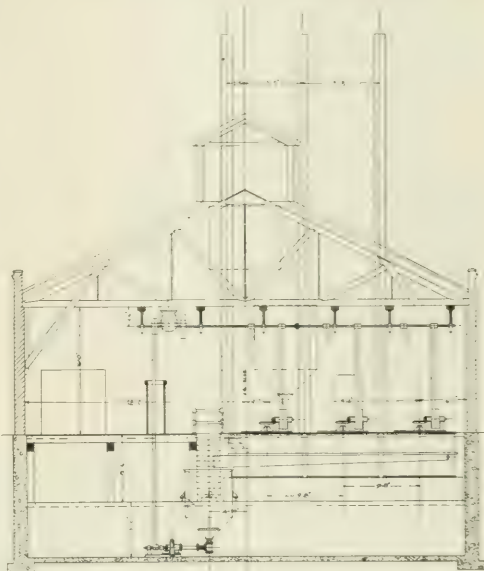
and the shell. The kettles rest on an iron top which is supported by the shell and to a certain extent by the brick work.

These may be heated by oil, gas or coal. Oil, however, is the most satisfactory.

There should be a combustion fire pot at the bottom of the setting of smaller diameter than the brick lining. The flame should strike this fire pot tangentially so as to give the gases a whirling motion in the furnace.

The kettles are equipped with a powerful stirring device of cast iron of modified horse-shoe type, that is, the blades are bent backwards in opposite direction so that they will throw the molten mass upward as well as around. It is a good plan to equip these kettles with breakers to further agitate the whirling mass.

The kettles are equipped with a thermometer tube, which may be of double extra heavy pipe with end



CROSS-SECTION OF FUSION BUILDING

welded or preferably of a rod of wrought iron bored out with a gun bit. The thermometer should be of the recording type with a flexible connection from the bulb to the recording instrument.

The kettles may be discharged through a bottom opening or by ladling out the fused mass. I have found the latter method to be the more satisfactory. The disadvantages of a bottom discharge more than outweigh its evident advantages.

The best general arrangement of the fusion kettles is to have them level with the floor so that the caustic soda and the salt may be charged into the kettle from the floor level. The kettles should be arranged in two rows with the floor level lower than the main floor level between them.

METHOD OF HANDLING FUSED SODIUM PHENOLATE

In the center of the space between the rows of kettles, a trough extends from one end to a conical-bottom tank at the other. This tank is provided at the bottom with a grid covered with a wire screen and at the bottom of the cone with a centrifugal pump discharging into the other end of the trough. When this tank is nearly filled with water and the centrifugal

pump started, it discharges a stream of water into the far end of the trough running back into the tank.

The hot fused sodium phenolate and excess of caustic, without any previous cooling, can be ladled from the kettle directly into the water in this trough, which readily dissolves the same. When a kettle has been entirely discharged the system is arranged so that the pump will discharge into the decomposing tanks.

WEAK ACID TANKS

These are yellow pine or cypress tanks, lead-lined, located over the decomposing tanks or acidulators. The space over these tanks must be well ventilated.

DECOMPOSING TANKS OR ACIDULATORS

These are of iron. Under some conditions it is necessary that these shall be lead-lined or made of cast iron. They shall have a cone bottom. Weak acid is brought to these tanks from the weak acid tank through a lead pipe which discharges near the bottom. They are arranged so that either compressed air or steam can be admitted near the bottom of the tank.

These tanks discharge through a sight glass arranged with a three-way cock so that the tanks can discharge to the sewer or to the crude phenol tank.

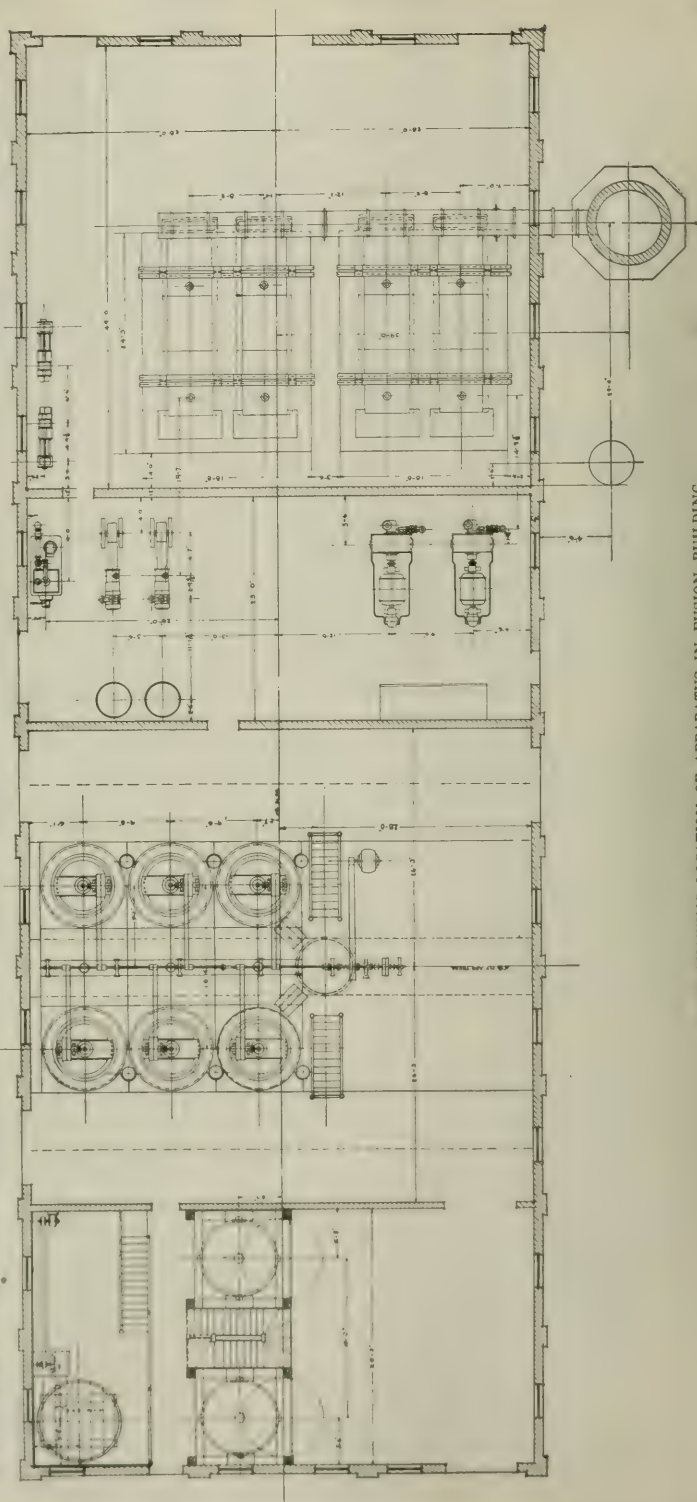
Between the separator and the sewer there should be a small tank arranged in the shape of a decanter so that in case any phenol is carried out with the waste solution it can be recovered from the top of this tank.

CRUDE PHENOL TANKS

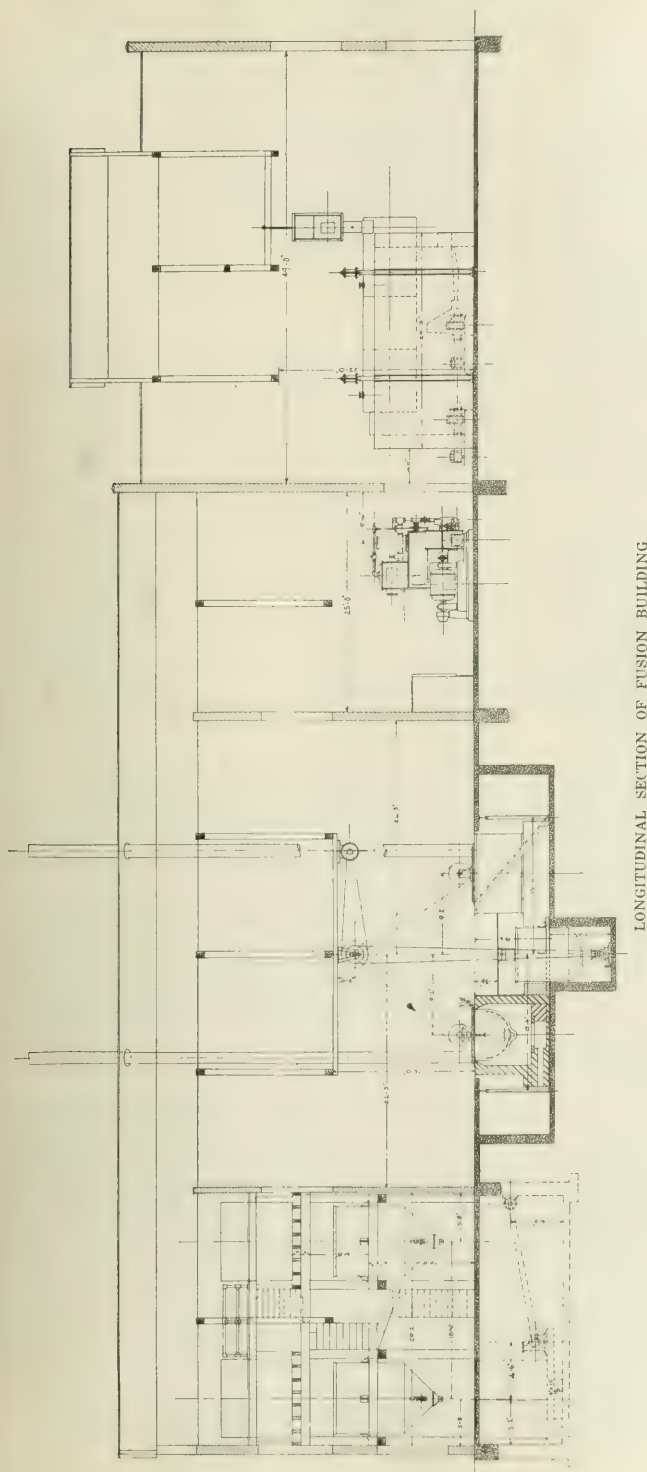
These are sheet iron tanks provided with indirect steam-heating coils. These should be of sufficient capacity to hold three days' production of crude phenol. From the fusion kettles to the crude phenol tank, the apparatus is all in one building.

REFINING STILL

The refining still, which is located in the first-mentioned building, should be of column type with dephlegmator. The condenser should contain silver tubes and all portions of the condenser coming in contact with the finished phenol should be silver or silver-lined. The pipes



PLAN SHOWING LOCATION OF APPARATUS IN FUSION BUILDING



from the condenser through the watch glass to the phenol tank should be silver-lined and the valves (flanged gate valves) extra heavily silver-plated. The phenol receiving tank should be enamel-lined and all valves and fittings in connection therewith should be silver or silver-plated.

Cooling water for the condenser, which, of course, is warm water, should circulate from the tank through the condenser, back through a cooler and into a storage tank. The cooler, which is similar to a tubular condenser, is piped with cold water which is so regulated that the temperature of the water in the phenol condenser can be held at a predetermined point. The apparatus in general should be liberally equipped with thermometers.

The phenol still is heated with indirect steam, large coils being used in the bottom of the still, which is a cylindrical tank, laid in a horizontal position. The manhole into this tank should be large enough so that the heating coils may be removed as a whole. This permits of a heating coil without joints. For a still of this type a wet vacuum pump is sufficient. The receiver for water fraction may be an iron tank. Finished phenol is drawn from the phenol receivers into the packages in which it is shipped.

POWER PLANT

Economy of fuel should be carefully considered. The following plan has been found to be very successful.

Engines or turbines exhausting against a back pressure of 15 lb. to the square inch; this 15-lb. exhaust line is carried through the sulfonating building and this steam is used in the evaporator to heat the storage tanks, etc., the condensed water from this system going to a hot-water tank.

The exhaust from all the pumps of every description and all compressors goes into a low-pressure exhaust line which goes to the hot-water heater, the feed-water heater and in winter to heat the building. The condensation from the heating system when in use goes to the hot-water tank.

There is a connection from the high-pressure steam lines through a reducing valve into the 15-lb. steam line in case the supply of steam to the 15-lb. line is insufficient. There is also a connection from the 15-lb. line through a reducing valve into the low-pressure line, in case there is an excess of steam in the 15-lb. line. There is a connection from the 15-lb. line to the low-pressure line through a reducing valve, in case the

supply of steam in the low-pressure line is insufficient and a connection from the low-pressure line to the boiler-feed water heater and to the atmosphere in case there is an excess of steam in the low-pressure line.

The boiler plant and the engine room, aside from the points mentioned, are of ordinary construction.

All machinery of the plant must be driven preferably by motors supplied with current from the generators which are driven by the turbines. Alternating current should be used to avoid any possibility of sparks which are common in direct-current motors.

In such a plant as this, the labor cost and fuel cost per pound of phenol is very low.

The best type of building construction is steel frame, brick walls, with a roof made of gypsum blocks.

The cost of a well-designed phenol plant to produce 10,000 lb. of phenol per day, brick and steel buildings, power plant, complete, is about \$200,000. A plant for making 20,000 lb. a day costs about \$250,000.

Moses, Pope & Messer,
New York City.

The Viscosity of a Thermolized Paraffin Base Oil

BY GUSTAV EGLOFF AND ROBERT J. MOORE

In the study of the thermal decomposition of hydrocarbon oils the physical constant of viscosity is of some significance. In this note the effect of temperature and rate of oil flow upon the viscosity of the thermolized oil has been studied.

The paraffine base oil used was subjected to temperatures ranging from 500 deg to 700 deg C. and rates of oil flow from 12 to 36 gal. per hour. The viscosity of the oils was determined by means of the usual method in oil technology the Standard Engler¹ Viscometer.

Experimental Data

Table 1 and Fig. 1 give the experimental data on the viscosities of a paraffin base oil thermolized at varying temperatures and constant rate of oil flow of 16 gal. per hour.

Table 2 and Fig. 2 give the experimental data on the effect of rate of oil flow on the viscosity of a thermolized paraffin base oil at constant temperature of 600 deg. C.

TABLE 1.

THE VISCOSITIES OF A PARAFFIN BASE OIL THERMOLIZED AT VARYING TEMPERATURES AND CONSTANT RATE OF OIL FLOW OF SIXTEEN GALS. PER HOUR

Temperature, deg. C.	500	550	600	650	700
Viscosity Engler Deg.	1.104	1.151	1.245	1.094	1.055

TABLE 2.

THE EFFECT OF RATE ON THE VISCOSITY OF A THERMOLIZED PARAFFIN BASE OIL AT CONSTANT TEMPERATURE

Rate, gallons per hour	12	16	22	30	36
Viscosity Engler Deg.	1.330	1.245	0.906	1.151	1.161

Discussion of Data

In the thermal decomposition of a paraffin-base oil the viscosity of the oil increased with increase of temperature to a maximum and then decreased as the temperature increased within the limits of the experiments. In Table 1 the maximum viscosity is noted at 600 deg. C. of 1.245 and the minima of 1.104 at 500 deg. C. and 1.055 at 700 deg. C. The effect of rate upon the viscosity at constant temperature of 600 deg. C. gave a minimum of viscosity 0.906 at 22 gal. per hour, and maxima of 1.330 at 12 gal. per hour and 1.161 at 36 gal. per hour.

Fig. 1 gives a maximum point and two minima in the viscosity with change of temperature; while a change

in rate gives a minimum and two maxima in Fig. 2. Greater decomposition of the starting oil takes place as the temperature is increased. This is a common phenomenon of the cracking of oils.² The opposite is the case when the rate of oil flow is increased, which is equivalent to the time factor³ in chemical reactions. As the oil is passed through a heated tube with increased rapidity as exemplified by changing the rate of oil flow from 12 to 36 gal. per hour, the changes taking place in the oil grow less and less until a rate is reached where no decomposition at all takes place. At

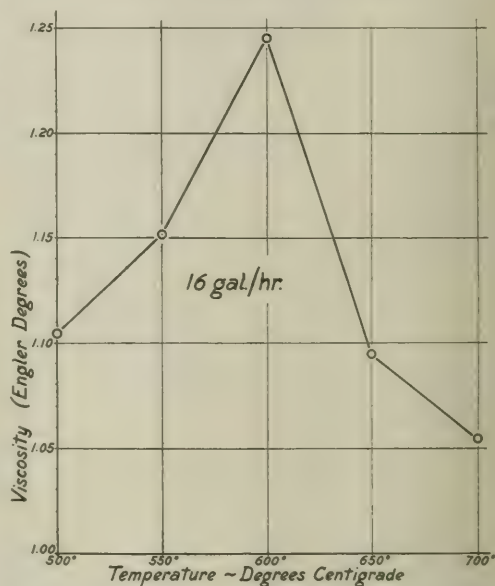


FIG. 1—VISCOSITY OF A PARAFFIN BASE OIL THERMOLIZED AT VARYING TEMPERATURES AND CONSTANT RATE OF FLOW OF 16 GAL. PER HOUR

12 gal. per hour and 600 deg. C. maximum decomposition of the starting oil took place with a resulting greater viscosity of the oil than the maximum temperature of 700 deg. C. and 16 gal. per hour gave. In short, the time factor in this series of experiments had a greater effect upon the viscosity than the temperature factor.

Theory

For mixtures of pure liquids the physical constant of viscosity is rarely a strictly additive property. The viscosity deviates from the additive law due to volumetric, thermal or molecular action between the constituents of the mixture. Perhaps this is due to the breaking down or building up of complexes in certain liquids due to surface tension⁴ and viscosity relationships which would indicate that solution of one liquid in another is quite similar in character to thermal effects upon the solution. Wijkinder,⁵ Lineberger,⁶ Thorpe and Rodgers⁷ have found experimentally that the viscosity of a mixture of miscible and chemically indifferent liquids is rarely if ever, under all condi-

¹Egloff and Twomey, *Jour. Phys. Chem.* 20, 121, 1916.

²Whitaker and Alexander, *Jour. Ind. Eng. Chem.* 7, 484, 1915.

³Morgan and Egloff, *Jour. Am. Chem. Soc.* 38, 844, 1916. Rittman and Egloff, *Jour. Ind. Chem. Eng.* 7, 575, 1915.

⁴Reid, *J. S. 1879, Jour. Chem. Soc.* 71, 361, 1897.

⁵Amer. Jour. Sci. 11, 331, 1896.

⁶Jour. Chem. Soc. 71, 361, 1897.

⁷Holde, *Reaktionsschritt in Hydrocarbon Oils* 1915. *Zett. f. Angew. Chem.* 725, 1892. *Industriell. Polytech. Jour.* 286, 210, 1892. *Chem. ZVtg.* 11, 1886.

tions a linear function of the composition of the mixture.

After thermal treatment the paraffin-base oil at 500 deg. C. was mainly composed of the paraffin and ethylene series of hydrocarbons with small amounts of aromatic compounds present. At 600 deg. C. the proportion of the aromatic series increased at the expense of the aliphatic hydrocarbons, while at the temperature of 700 deg. C. the thermolized oil contained mainly aromatic compounds of the benzene series. A satisfactory explanation of an increase of viscosity with increase of temperature and then a decrease as the temperature reached 700 deg. C. cannot be given as the complexity of the mixture of hydrocarbons is too great.

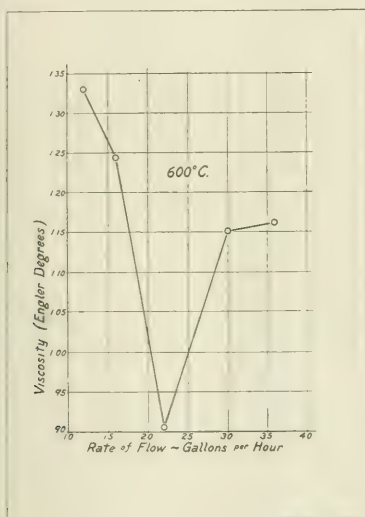


FIG. 2—EFFECT OF RATE OF FLOW ON THE VISCOSITY OF A THERMOLIZED PARAFFIN BASE OIL AT CONSTANT TEMPERATURE

From the data⁷ of the viscosity of individual hydrocarbons of the paraffin, ethylene and benzene series some approximations may possibly be made as to the maxima and minima of the viscosities of the oils reported in this investigation. Dunsten and Thole in their book, "The Viscosity of Liquids," have shown that in homologous series there is an increase in viscosity corresponding to an increment of CH_2 , but the increase tends to diminish as the molecular weight increases. Increase of carbon atoms in the molecule decreases the viscosity. Unsaturation increases the viscosity of the liquid. The viscosity of the benzene series is greater than the paraffin series.

As the temperature increases the viscosity of the treated oil increases which may in part be explained upon the basis of increased formation of the aromatic compounds of the benzene series and unsaturated hydrocarbons up to a definite temperature.⁸ As the decomposition reaction continues heterocyclic compounds are formed of naphthalene, anthracene and their methyl derivatives¹⁰ and higher polycyclic hydrocarbons of which little is known. The greatly increased carbon content in the hydrocarbons of the latter type, one may infer from the work of Rellstab¹¹ indicated that

the viscosity decreases with increase of carbon content. The physical constant viscosity is an exceedingly complex phenomenon, however, and in view of the immense amount of work yet to be done upon the polycyclic hydrocarbons, the above theoretical considerations as applied to thermolized oils, are not inclusive.

Summary

1. A theoretical explanation has been given as to the phenomena of viscosity as applied to complex mixtures of aliphatic and aromatic hydrocarbons resulting from the thermal decomposition of a paraffin base oil.

2. The viscosities have been determined of a paraffin base oil thermolized at varying temperatures. The maximum in viscosity 1.245 was found to be at 600 deg. C. and constant rate of flow of 12 gals. per hour. The minimas of 1.104 at 500 deg. C. and 1.055 at 700 deg. C. at the same rate are recorded.

3. The effect of the rate of oil flow upon the viscosity of a thermolized paraffin base oil has been determined. The minima in the viscosity was found to be 0.906 at 22 gal. per hour and maximas of 1.330 at 12 gal. per hour and 1.161 at 36 gal. per hour.

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Notes from the Palmer Physical Laboratory

BY E. F. NORTHRUP

Measurements of Resistivity and Thermal Electromotive Force of Samples of Calcium, Aluminium, Magnesium, Alloys of Aluminium and Magnesium and the Thermal E. M. F. Curve of Nickel vs. Nichrome

The writer is greatly indebted for the samples herein after known as Nos. 1 to 6 inclusive, to Dr. W. R. Whitney who presented them to him to be used for experimental purposes. He is also indebted to the Aluminum Company of America for the very pure sample of aluminium and its chemical analysis. The measurements of resistivity and a report on the results obtained were made by the writer's students, Mr. L. D. Howell and W. van B. Roberts. The data on the thermal e.m.f.'s were obtained and reported on by the writer's students, Mr. A. J. Mundt and Mr. B. S. McCutchen. The curve of the thermal e.m.f. of nickel vs. nichrome was obtained for the writer by Mr. L. A. Cavalcanti.

Resistivity Measurements

The measurements made were confined to the temperature range 20° to 150°C. Resistivity measurements were made on the following samples, all in the form of wires under 0.23 cm. in diameter:

- (1) was pure magnesium.
- (2) was 87.5% aluminium + 12.5% magnesium. Cold drawn.
- (3) was 10% aluminium + 90% magnesium.
- (4) was 90% aluminium + 10% magnesium. Cold drawn.
- (5) was 90% aluminium + 8% magnesium + 2% nickel. Cold drawn.
- (6) was pure calcium.
- (7) was 99.67% Al., 0.16% Si., 0.15% Fe., 0.02% Cu. and was annealed by heating red hot and cooling in air.

*FOREWORD.—This is the first of a series of reports which the writer plans to give in the columns of METALLURGICAL AND CHEMICAL ENGINEERING of work done by the writer and students and assistants working under his direction, at and with the facilities of the Palmer Physical Laboratory, Princeton, N. J.

⁷Landolt and Börnstein, Tabellen.

⁸Egloff and Twomey, MET. AND CHEM. ENG. 14, 247, 1916.

¹⁰Egloff, MET. AND CHEM. ENG. 15, Aug. 1, 1916.

¹¹Rellstab, Diss. Bonn, 1868.

(8) was the same wire as (7) but not annealed by us.

APPARATUS USED

Kelvin double-bridge (Leeds and Northrup, catalogue number 4307).

Sensitive galvanometer (Leeds and Northrup, catalogue number 2280).

Wheatstone bridge.

Galvanometer (Leeds and Northrup portable type).

A German silver coil of about twenty ohms for heating.

A well aged copper coil used as a resistance thermometer of about 6.5 ohms and of about the same length as the samples.

Adjustable resistances, pan of oil, mercury thermometers, storage cells.

PROCEDURE

The resistance of the specimens was measured with a Kelvin double-bridge used with a Leeds and Northrup sensitive galvanometer. (Consult, *Methods of Measuring Electrical Resistance*, by E. F. Northrup. See, for general treatment of the Kelvin double-bridge, *arts.* 609-614, and for description of particular apparatus used, *arts.* 706, 1505.)

The specimens were held in a frame under suitable clamps. The potential point contacts were obtained with knife-edges held down with spring-pressure. The frame and sample were placed in a long narrow tank under kerosene oil. A thoroughly aged copper coil about 0.4 cm. in diameter and of about the same length as the distance between potential points, approximately 38 cms., was located close alongside the specimen. This coil, used as a resistance thermometer, served as the standard of temperature. The relation between its resistance and temperature was previously very accurately determined at the ice-point and the boiling-point of water. As the resistance-increase of copper with temperature in the temperature range 0° to 100°C. is strictly linear, the temperature of the coil, and hence the average temperature of the sample in close association with the coil, was very accurately determined from a resistance measurement of the coil. As an additional precaution against error in determining the temperature of the sample, the oil was stirred at the time a measurement was being made and all readings were taken when the temperature of the oil was nearly stationary.

The heating of the oil was effected by means of a heating coil of resistance wire immersed in it. As the oil cools slowly, when the heating current is turned off, a more rapid lowering of the temperature was occasionally obtained by adding cold oil to the tank. By stirring and adjusting the current through the heating coil it was not difficult to maintain the oil at nearly equilibrium temperature at the intervals at which measurements were made. A resistance coil, like the one described above, is very superior to a thermocouple, resistance-thermometer or other device which gives the temperature at a point. The reason is that the resistance-thermometer coil being of the same length as the distance between the potential points of the sample being measured gives the mean temperature of the sample between potential points, and, if the sample has a nearly constant temperature coefficient, inequalities in the temperature of the oil or the sample between the potential points introduce no error; for it can be considered that the resistance of the coil gives a mean temperature and since the variation of temperature along the length of the coil and sample is the same, the resistance of the sample is its resistance at the temperature deduced from the coil. This is strictly true when the resistance of both the copper coil and the

sample are linear functions of the temperature or if they are similar curves.

To obtain the temperature from the resistance of the coil we referred to a large chart on which the resistance of the coil had been plotted against temperature. The temperature readings were also occasionally verified by using a mercury thermometer carefully corrected and reading to tenths of a degree and hundredths by estimation.

The resistivity of a sample was calculated from the measured resistance. For this calculation it was necessary to measure the length between the potential points and the diameter of the sample. Diameters were obtained by taking the mean of numerous readings of diameter made with a Brown & Sharpe micrometer calipers at various points along the wire and various points around it.

The sensitivity of the measuring outfit was such that a relative error of more than one unit in the last place of decimals would become quite evident. Following a common practise of the writer the Kelvin double-bridge measurements were several times checked during the investigation by transferring without other change in the set up, the current and potential leads to a low-resistance standard known to be correct. When the outfit measured this standard correctly assurance was given that the measurements of resistance were being correctly made.

It seems certain, therefore, that, when measurements on a sample were several times repeated, the sample in the meantime having been heated or cooled between the different measurements, and the resistivity at a given temperature was found to vary (in some cases as much as 2 per cent) this variation cannot be due to errors of measurement. Rather it is shown by the measurements that within rather narrow limits the resistivity of several of the samples depends not only upon the temperature but also upon the previous thermal history of the sample; that is, whether before the measurement it has been heated or cooled and how fast. Slow cooling seems to leave the resistivity slightly diminished.

The absolute values of the resistivities are not only dependent upon the heat treatment of the sample, but are subject to an error in determination which may amount to as much as one-half to two per cent resulting from the difficulty of accurately estimating the cross-section of the samples from micrometer readings of the diameters of the wire. All relative values are certainly correct to within 0.2 per cent.

DATA AND RESULTS

The data used for deducing resistivity from resistance is given in the table below:

DATA FOR DEDUCING RESISTIVITY FROM RESISTANCE

Sample	Length Between Pot. Pts. in Cms.	Mean Diameter in Cms.	Mean Section in Sq. Cms.	k Section Length Resistance Divided by Resistance R	Probable per Cent Error in k and Hence in ρ Estimated
1	42.9	102	00817	0002482	2
2	38.2	1064	00880	0002327	2
3	38.32	1009	00800	0002006	1
4	48.34	10503	00806	000223	0.4
5	38.2	08138	0052	0001362	0.4
6	22.4	12165	01192	00521	0.4
7	38.9	2254	0399	001025	1.0
8	43.1	2254	0399	00111	

The sample of calcium wire (sample No. 6) is (according to a statement made to the writer by Dr. Whitney) taken from a lot made by the Research Laboratory of the General Electric Co. which is probably the first wire ever drawn of pure calcium. No analysis was supplied to the writer but the wire was stated to be of pure calcium. If exposed to damp air it oxidizes slowly

superficially and the sample was preserved under paraffin. The oxidization is not, however, too rapid to prevent the wire from being handled for purposes of micrometering it. It was, of course, under oil while the measurement was being made. The resistivity of this sample was 5.32 microhms at 20°C. and 6.64 microhms at 100°C. per cm². This resistivity of calcium is therefore but slightly greater than pure magnesium which for the sample tested was 4.75 microhms per cm² at 20°.

It was found that although aluminium and magnesium both have low resistivity their alloys have a considerably higher resistivity than either of the constituents and that increasing the proportion of magnesium greatly increases the resulting resistivity. Thus, at 20°C. sample No. 4 consisting of 90 Al. + 10 Mg. has a resistivity of 8.28 microhms, while sample No. 3, consisting of 10 Al. + 90 Mg. at the same temperature has more than twice the resistivity, 19.18 microhms per cm².

The curve sheet, Fig. 1, embodies the results obtained in the measurements and will be understood without further comment. However, as the resistivity varied with repeated heatings and coolings, another curve, No. 2, is given which shows the striking manner in which this change in resistivity occurs in the case of the alloy 90 Mg. + 10 Al., namely, sample No. 3. The occurrence of this phenomenon happened to some extent with all the samples and it took a very long time to conduct the many series of measurements required to satisfy ourselves that the resistivity of the samples was really changing and that the measurements were in no wise in error.

As the writer has stated in previous communications many metals and most alloys when in the solid state

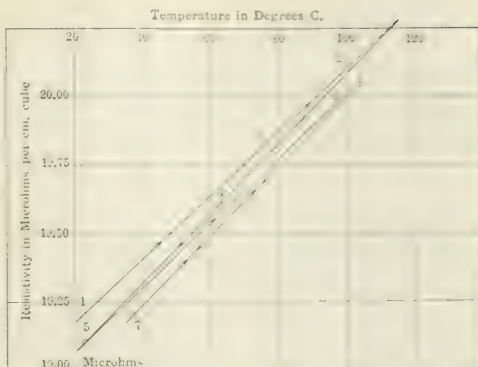


FIG. 2—RESISTIVITY OF ALLOY 90 PER CENT Mg. AND 10 PER CENT AL.

Points 1 to 2, slow heating; 2 to 1, slow cooling; 1 to 6, slow heating; 6 to 7, slow cooling; 6 to 8, heated by removing metal and pouring in hot oil. It will be noted that the last curve up is identical with the previous one down.

will have a resistivity which is more or less dependent upon past physical history, and if, therefore, we wish to obtain resistivity measurements for samples which have a resistivity dependent only upon temperature and chemical composition, we must bring the samples into the molten state. (See numerous articles by the writer in the *Journal of the Franklin Institute*, beginning in February, 1913.) In the case, however, of a very pure metal as copper, platinum or nickel which has been drawn into wire and then thoroughly "aged" by prolonged heating, the resistivity will become a function of the temperature only, if the temperature is maintained below that at which the sample was aged. If this were not so pure metals could not be relied upon as satisfactory pyrometric substances for use in resistance thermometry.

Determinations of Thermal Electromotive Force

The object sought in the series of measurements described below was to determine the thermal e.m.f. at various temperatures developed in a thermocouple made from the General Electric Company's samples Nos. 1 to 6 as described above, also the sample of aluminium, No. 7, all against pure copper; and an additional series of measurements were thought to be desirable on the combination pure nickel vs nichrome, for reasons which will appear later.

Arrangements were made so that all readings of e.m.f. would be given to the units place in microvolts. With the exception of the nickel vs. nichrome combination, which was studied in a slightly different manner, the following procedure was adopted:

The method of measurement.—Accurate temperature points were obtained by making use of the following fixed points: The boiling-point of water, the freezing-point of tin, and the freezing point of zinc. The e.m.f.'s of the various samples developed at these points when the cold junctions of the couples were in an ice-bath were read with a potentiometer. The apparatus employed consisted of a Leeds and Northrup potentiometer and galvanometers, a Weston standard cadmium cell, a small electric furnace wound with nichrome ribbon, a small Dewar flask filled with cracked ice, a hypsometer and some small accessories. The electrical connections employed are shown in the diagram Fig. 3.

The first step was to construct thermocouples using the various samples against Cu. The details of construction are sufficiently shown in Fig. 3. A is a small

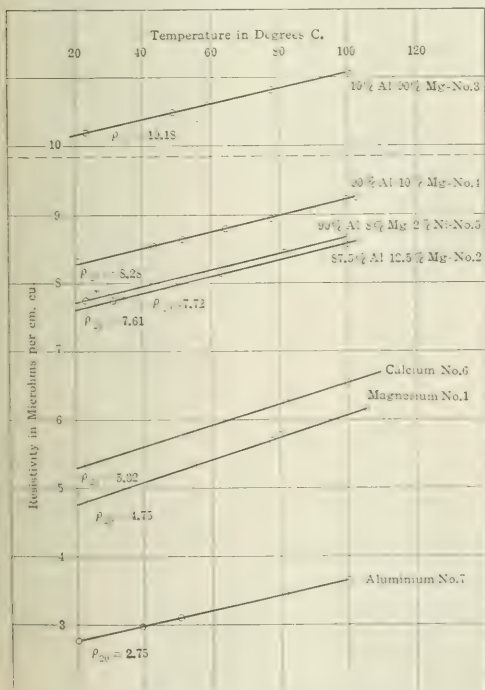


FIG. 1—CURVES OF RESISTIVITY AS FUNCTION OF TEMPERATURE

quartz tube, and B is a protecting tube of Marquardt ware. It was found impossible to weld the junctions and hence a mechanical connection was resorted to. This was made by flattening the ends of the wires and wrapping them with fine Cu. wire. The apparatus was set up as shown in Fig. 3 for obtaining the melting points of metals and the hot junction was placed in the hypsometer for the 100° point.

The e.m.f.'s generated were read, while steam was

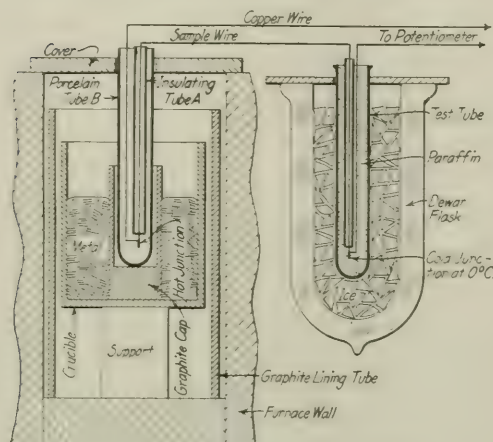


FIG. 3—EXPERIMENTAL ARRANGEMENT

pouring out freely. The barometer was read and the correction for boiling-point found. Six readings were taken and the average value used. The other junction during these experiments was kept at zero degrees Centigrade by being placed in the Dewar flask filled with cracked ice.

The tin-point and zinc-point were obtained as follows: The metal was placed in an aluminum thimble which was located in a small, vertical, nichrome-wound tubular furnace. The inner wall of the heating tube was lined with a graphite tube so that when the furnace was heated above a red heat a reducing atmosphere would be developed. This is desirable and, in fact, necessary, when one is obtaining the copper-point, to preserve the metal free from oxidation on its surface.

The hot junction of the couple was slipped into a small tube of Marquardt and this in turn was slipped into a very thin-walled graphite tube closed at the bottom end. The hot junction thus protected was immersed in the molten metal.

The heating current of the furnace was either shut off or reduced and readings of e.m.f. were made on the potentiometer at frequent intervals as the metal cooled. As is well known the temperature of the metal holds stationary while solidification is occurring and the e.m.f. of the couple read at this time is the e.m.f. which it develops at the temperature at which the metal freezes. Both in the case when obtaining the tin-point and the zinc-point the metal was heated and allowed to cool until quite solid and then again heated and again allowed to cool, this being repeated at least four or five times. The successive readings of the e.m.f. taken at the freezing-point of the metal were found to agree almost exactly.

The method described above was followed for all samples except No. 6 (pure calcium) for which the following procedure was adopted. The hot junction was placed in a kerosene bath which was heated electrically, the cold junction being maintained at zero degrees Cen-

tigrade in the Dewar flask. The temperature was read by means of a resistance thermometer, all points being determined while the oil-bath was cooling and after it had been well stirred. For points above 100°C. the hot junction was placed in a protecting tube filled with Crisco, which stands a much higher temperature than oil. A mercury thermometer was bound to this tube and the unit so made was placed in the furnace.

Tables I and II of data obtained on sample No. 4 (90 Al + 10 Mg vs Cu) and sample No. 6 (Ca vs Cu) will explain the manner of taking the readings and the general character of the results obtained:

TABLE I—DATA SHEET OF SAMPLE NO. 4

Barometer reading, 77.13 cm.	E. m. f.'s at boiling point of water in microvolts.
Corrected boiling point, 100.4.	228
	227
	228
	227
	225
	222
	226.2 aver.

FREEZING POINT OF TIN		FREEZING POINT OF ZINC	
Time	E. m. f.	Time	E. m. f. Microvolts
3:13	1003	3:08	2268
14	1087	09	2310
15	1077	10	2240
16	1041	12	2173
17	1007	13	2084
18	918	14	1997
19	884	15	1829
20	843	16	1837
21	807	17	1776
22	754	18	1691
23	736	19	1645
24	692	20	1598
25	692	21	1598
26	692	22	1598
27	692	23	1598
28	692	24	1598
29	692	25	1598
30	692	26	1598
31	692	27	1598
32	687	28	1598
33	677	29	1582
		30	1483

Freezing point of tin, 231.9 degrees C.*

E. m. f. at tin point, 692 microvolts.

Freezing point of zinc, 419.4 degrees C.*

E. m. f. at zinc point, 1598 microvolts.

*Geophysical laboratory values.

TABLE II. DATA SHEET ON SAMPLE NO. 6, CALCIUM WIRE.

The following points were determined with the sample under kerosene oil:

TABLE II—DATA SHEET ON SAMPLE NO. 6, CALCIUM WIRE

Temperature in Degrees C.	E. m. f.'s in Microvolts
24	218
51.2	514
56	558
89	840
90.4	968
92	1000
96	1027

The curve for calcium (Fig. 4) was plotted from the above results. An attempt was made to observe the e.m.f.'s developed up to 335 degrees, using Crisco to protect the wire from oxidation. No consistent results, however, were obtained due to the occurrence of frequent open circuits at the hot junction caused by oxidation of the calcium wire at the joint. The point indicated as the freezing point of tin on the Summary Data Sheet (Table II) was found by extrapolation.

The direction of the e.m.f.'s generated was found to be through the hot-junction from the sample to the Cu. in every case.

The results contained in the following table are all plotted in curves Fig. 4.

TABLE III—SUMMARY OF DATA OBTAINED

	Freezing Point of Water	E.m.f.s. generated at Boiling Point of Water	Freezing Point of Tin	Freezing Point of Zinc
No. 1	0	301	810	1737
No. 2	0	215	682	1555
No. 3	0	500	1374	2862
No. 4	0	236	692	1598
No. 5	0	255	703	1635
No. 6	0	1080	3080*	
No. 7	0	372	930	2934

*See special data sheet on this sample

The curve, Fig. 5, for the thermal e.m.f. of very pure nickel vs nichrome (made by Driver-Harris Co.) was obtained for the writer by Mr. L. A. Cavalcanti and is interesting from two standpoints. First it gives results obtained by a well-known method which may be used with great ease by any one for very accurately calibrating a thermocouple up to the temperature of freezing copper (1082° C.), no use being made of any instrument, thermocouple or resistance thermometer to serve as a standard of temperature.

The method gives with great simplicity five accurate points for tracing a curve, which number is quite sufficient for ordinary purposes. The method is quite similar to the one, just described, which was used in determining the thermal e.m.f.s. of the different General Electric Co.'s samples.

A small nichrome-wound furnace arranged to stand vertical, with a chamber large enough to hold a crucible of graphite one inch in diameter and about three inches high, serves admirably the purpose of a heat-producing apparatus. The bottom of the furnace-heating tube should be tightly closed and the thermocouple tube should be passed through a small hole in the cover of the furnace, which should fit tightly (see Fig. 3). The graphite of the crucible, immediately a red heat is obtained, converts the atmosphere in the furnace chamber into a reducing atmosphere which preserves the surface of the metals (Sn, Zn, Sb and Cu used for giving fixed points of temperature), free from oxidation.

A crucible should be provided for each metal employed and each crucible about two-thirds filled with a partic-

ular metal, may be used over and over again, and so serve the purpose of giving a fixed-point of temperature for many thermocouple-calibrations.

There should also be provided as many graphite tubes (closed at the bottom and with a wall less than a mm. thick), as there are metals used. These graphite tubes serve as a cap (see Fig. 3) which fits over the end of a

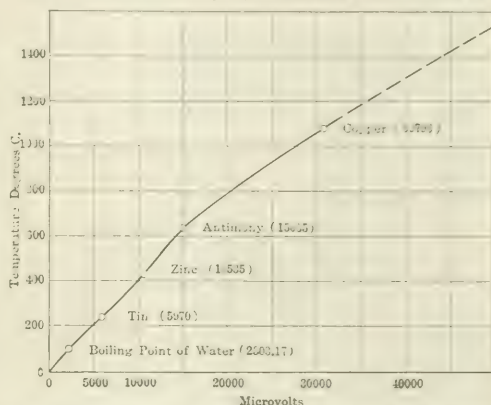


FIG. 5—THERMAL E.M.F. CURVE FOR NICHROME VERSUS NICKEL THERMOCOUPLE

thermocouple, loosely. This cap will prevent any undue strain being exerted on the casing of the thermocouple when the metal, in which the thermocouple is immersed, freezes and contracts and the thermocouple may be removed from the crucible containing the solidified metal without reheating.

It was with this method, as just described, that each of the points, except the boiling point of water, was obtained for plotting the curve shown in Fig. 5. The e.m.f. was, of course, read with a potentiometer at the time a metal was in the process of freezing, and the temperature and e.m.f., consequently, remained for a certain interval constant.

The curve, Fig. 5 is, secondly, very interesting because it shows that there is an interval of temperature (between 350° and 500° C.) in which the curve makes a slight inflection, the e.m.f. not increasing in the regular way with increase in temperature that it does outside this interval. This is probably due to the fact that nickel has a recalcence point in the neighborhood of 360° C. As a combination of any of the metals of the iron group with nichrome give a high thermal e.m.f., and as all these metals have high melting-points they would naturally be considered very useful as one metal in a combination for a base-metal thermocouple. The fact, however, that the curve shows a change in its regular course near a recalcence point of a metal belonging to the iron group, should at least put one on his guard against too implicit reliance on the accuracy of the temperature indications of a thermocouple in which nickel or nichrome forms one element, in the neighborhood of the temperature of recalcence. This change in the course of the curve may not exist in the combination cobalt vs. nichrome; but should be looked for very carefully.

In the combination nickel vs. nichrome the e.m.f. acts to send current from nickel to nichrome through the hot junction.

The experimental work described above was done between January and March, 1916.

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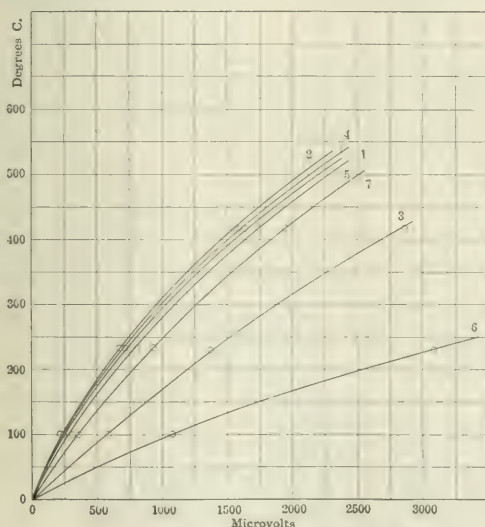


FIG. 4—CURVES OF THERMAL E.M.F.S.

The Principles of Filtration

BY D. R. SPERRY

Filtration consists of the process of separating the solids from a mixture of solids and liquid by causing the liquid to flow away from the solids through a porous mass the openings of which are too small to allow passage of the solids.

The porous mass is called the filtering medium and is composed of two parts: that which was provided in order that filtration might begin, called the filter base, and that which was formed during filtration, called cake, consisting of the solids which were too large to pass through the openings of the porous mass.

The mixture of solids and liquid is called the mixture, while the liquid which was separated from the mixture is called the filtrate.

THREE INDISPENSABLE CONDITIONS OF FILTRATION

There are three indispensable conditions of filtration:

1. There must be a difference of pressure between the two faces of the porous mass, the higher pressure being on the side in contact with the mixture. The intensity of this pressure difference must be great enough to cause the liquid to flow through the porous mass. Without this pressure there would be no flow through the filtering medium, and hence no filtration.

2. There must be a filter base. If there is no filter base, there is no porous mass with which to start filtration, and therefore no filtration at all. In practice the filter base often consists of cloth or paper.

3. There must be a filter. A filter consists of a device employed to support the filter base and to confine the mixture so that the same may be placed under pressure and in contact with the filter base.

Inasmuch as there is a difference in pressure between the two sides of the filtering medium it follows that the low-pressure side must be supported. If this is not done the filter base will not remain in place and filtration will not result. Also, if the mixture is not held in place on the filter base it will flow away and filtration will not take place. A filter is therefore indispensable.

FILTRATION IN DETAIL

In order more clearly to comprehend the process of filtration, Fig. 1 is presented.

At *A* a mixture is shown in a confined space and in contact with a filter base *X*. Directly below is shown a receptacle to catch the filtrate. At the instant shown, filtration is at the very point of starting. Here can be observed the importance of the filter base, for at this step it comprises the entire filtering medium. At no other point in the process of filtration is this true. It initiates filtration, supplying for the time being the porous mass which later will be composed mostly of solids from the mixture.

At *B* flow of the liquid through the porous mass has proceeded for a certain length of time. The liquid or filtrate has collected in the receptacle below, while the

solids, unable to pass through the porous mass with the liquid, are necessarily left as a deposit *Y* upon the filter base. The filtering medium now no longer consists of the filter base only, but of two parts, the filter base plus the deposited solids or cake. It should be observed that the liquid now has to pass through a porous mass of greater thickness than in the case at *A*; consequently, assuming the pressure of the mixture to be constant, its rate of flow will be decreased.

At *C* an interval of time has elapsed from the state at *B* sufficient to double the amount of filtrate caught in the receptacle. As a result, assuming that equal quantities of liquid carry equal amounts of solids, the thickness of cake is twice that found at *B*. Since the liquid must flow through this greater depth of porous mass, its rate of flow is necessarily much less at *C* than it was at *B*.

At *D* still another interval of time has passed—enough so that the filtrate in the receptacle is twice that found at *C*. This doubles the thickness of cake over that found at *C*, resulting in a further decrease in the rate of flow of the liquid.

TWO PROCESSES AT WORK

A careful study of Fig. 2, in the light of the details

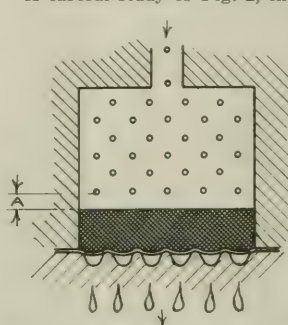


FIG. 2—CONDITIONS DURING ONE INSTANT OF FILTRATION

just given, will disclose the fact that there are two distinct and constantly changing processes going on, as follows: (1) Flow of liquid through porous mass; (2) building up of the porous mass or cake. These two processes are constantly changing because the liquid as it flows into the cake is continually leaving its solids behind, thus constantly increasing the thickness of the

porous mass, while simultaneously with this action the liquid is continually decreasing its own rate of flow, due to the increasing thickness of solids through which it has to pass.

It is now evident that if an expression showing the relation between these two processes can be devised and the laws of each are determined, the two can be combined in a known relation, thus deriving the fundamental laws of filtration.

RELATION BETWEEN THE TWO PROCESSES

In Fig. 2 is illustrated a cross-section of a filter in which the process of filtration is proceeding. A study of the instantaneous conditions there depicted reveals the fact that the rate of flow of the liquid through the porous mass is, at that moment, equal to the rate of flow which would obtain were there liquid only above the same. This can be best comprehended by considering the layer of liquid *A*, for it can readily be seen that during the instant this layer is entering the cake the conditions are the same as though liquid only were above. In actual conditions, of course, the particles of solids are not liable to be equally spaced in the liquid, but the effect in principle is the same.

The relation between the two processes—flow through cake and thickness of porous mass—can now be set down as follows: Rate of flow at any instant = rate of flow for liquid only through the thickness of porous mass at that instant.

The relation between the two processes being now

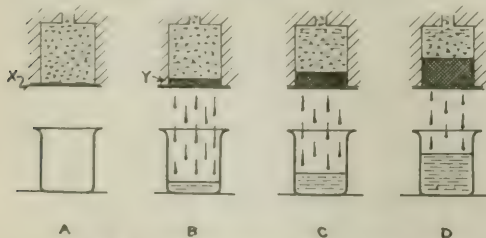


FIG. 1—FOUR STAGES OF FILTRATION

established, the next step is to investigate separately the laws governing each, and then by means of the common relation combine the two sets of laws to form the fundamental laws of filtration.

The First Process—Rate of Flow Through the Porous Mass

To investigate the laws governing the flow of liquids through a porous mass, the apparatus shown in Figs. 3 and 4 was employed. The method consisted in actually depositing a cake by the process of filtration upon a suitable filter base, and then measuring the rate of flow through the cake under various pressures with clear liquid only.

The apparatus consists of a small filter press having one plate and frame, the filter base being in a horizontal plane. This latter was done in order to minimize the effects of sedimentation as much as possible in order to secure a cake of uniform thickness. At the beginning of the test a piece of No. 10 duck *E* was laid upon the filter plate *F*. Upon the duck was placed frame *D*, while upon *D* was placed the head *C*, with a thin packing between them. Pressure was then applied mechanically so as to squeeze the pieces together. The pipe connection on the head was piped to a hand pump *A* on one side, and to a general water system *B* on the other. Valves were placed so that feed could be obtained from either source.

In the mixture tank were placed 3 quarts of water and $1\frac{1}{2}$ ounces of kieselguhr.* This material was selected because the particles of which it is composed are insoluble in water and quite rigid, thus avoiding errors due to leaching effects or change in shape of the solids.

After thoroughly agitating the mixture it was pumped into the filter chamber at 60 lb. per square inch pressure. This pressure was continued until about 1 quart of filtrate was obtained. At this point pumping was discontinued and the valve leading to the general water system was cracked just enough to keep the pressure constant at 60 lb. per square inch. The valve leading to the pump was then closed, and in order to assure complete deposition of the solids which were still in suspension within the frame, water was allowed to run from the filter until about three-fourths of a quart had escaped. The rate of flow was then measured, the gage showing 60 lb. per square inch.

Next the valve to the general system was closed just enough to show 50 lb. per square inch on the gage. The rate of flow was then measured. This process was kept on in decrements of 10 lb. per square inch until 10 lb. per square inch was reached, at which point the valve was closed entirely, the head removed and the approximate thickness of cake measured. Temperature was maintained at constant value throughout the test. The data obtained are given in Table I.

*A typical analysis of the Kieselguhr as used is given by the producers thereof as silica, SiO_2 , 89.17 per cent; alumina, Al_2O_3 , 1.65; iron oxide, Fe_2O_3 , 0.54; titanium oxide, TiO_2 , 0.03; lime, CaO , 0.54; magnesia, MgO , 0.52; loss on ignition, 6.64.

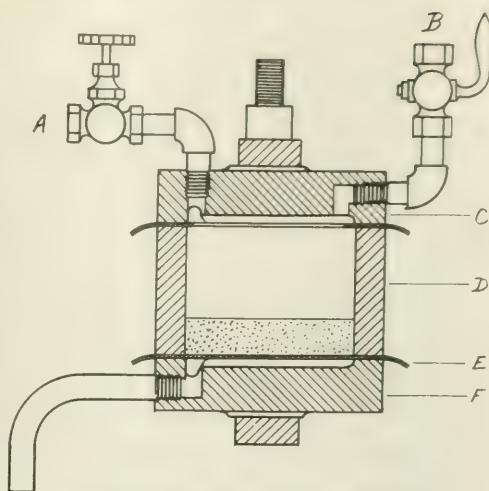


FIG. 3—EXPERIMENTAL FILTER PRESS

TABLE I

Date of test, March 29, 1915.
Place of test, Basement Laboratory, 178 Union Avenue, Batavia, Ill.
Temperature, about 65 deg. Fahr.
Filter base, No. 10 duck.
Mixture, $1\frac{1}{2}$ ounces of kieselguhr in 3 quarts of water.
Filtering area, $1/20$ sq. ft.
Apparatus, as shown in Figs. 3 and 4.
Pump, $1\frac{1}{2}$ -in. x 3-in. stroke, single-acting, hand-operated.

Method of Procedure:

- (1) From 5:16 p. m. to 5:18 p. m. pumped mixture in filter at 60 lb. per square inch until 1 quart of filtrate was obtained.
- (2) Opened valve to water system at 60 lb. per square inch and closed valve on pump line.
- (3) Allowed water to flow from filter until about 12 ounces was collected.
- (4) Regulated pressure by cracking water valve and made reading as follows:

Water Pressure	Time of Reading, P. M.	Flow of Water, Fluid Ounces	Rate of Flow in Cu. Ft. Per Hr.
60	5.22 to 5.25	26	4.06
50	5.26 to 5.29	21	3.28
40	5.30 to 5.33	17	2.66
30	5.34 to 5.37	12.5	1.95
20	5.38 to 5.41	8.5	1.33
10	5.43 to 5.46	4.2	.656

Remarks

Cake found to be about $\frac{1}{2}$ in. thick.

Cloth showed grooving or deformation apparently the same as observed at conclusion of tests made with ascending pressure increments.

Cake showed very faint coloration on surface in contact with water only.

The plotted results from the test are shown in Fig. 5.

Perhaps the most interesting result of this test is the fact that it shows that the rate of flow of the liquid through the cake varies as the first power of the pressure.

So straight a curve was not obtained, however, at the



FIG. 4—VIEW OF FILTER, OPEN ON LEFT, CLOSED ON RIGHT

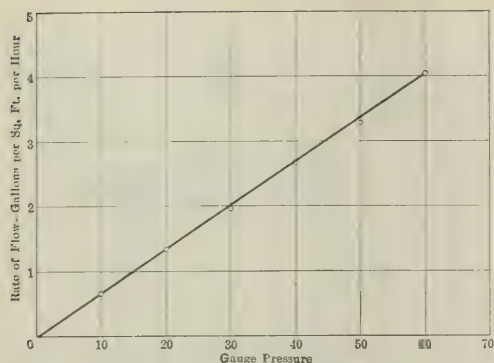


FIG. 5—EFFECT OF PRESSURE ON RATE OF FLOW OF WATER THROUGH FILTER CAKE OF KIESELGUHR

first trial. In previous tests the rates of flow were measured in ascending instead of descending increments. Under these conditions it was quite impossible to secure a straight-line curve. Careful examination of the cakes disclosed the fact that this was due to the drawing away of the edges of the cake from the sides of the frame due to the deformation of the filter cloth with the increasing pressure. This condition resulted in the exposure of an abnormal surface and the development of shorter porous paths to carry away the liquid. This caused the curve to bend upwards with increasing pressure.

A slight brownish coloring left by the liquid as it entered the cake showed conclusively that it gained entrance on the sides as well as top. A study of the cloths at the finish of ascending and descending tests, the maximum pressure being the same in both cases, showed a deformation or ridging the same in each instance. This would indicate that once a filter cloth is deformed by pressure the deformation becomes permanent. Examination of descending test cakes showed a brownish coloring on the top only, indicating that the liquid did not enter the cake at the sides.

FLOW THROUGH FILTER CAKE A CAPILLARY PHENOMENON

To many the fact that the rate of flow through a filter cake varies as the first power of the pressure will be looked upon as rather singular. Most would expect the rate of flow to vary as the square root of the pressure according to the law of falling bodies and the various flow-through-pipes formulas found in works of hydraulics and in handbooks.

It has long been known, however, that there are two distinct kinds of flows of liquids through tubes, namely, sinuous and non-sinuous. The first has been also called eddying, while the second has been called eddyless, parallel, direct or capillary flow.

If water under very calm conditions is caused to flow through a smooth tube with flared inlet at very low pressure, and then the pressure is very gradually increased, the flow for a time through the tube is very smooth and even, the rate of flow varying as the first power of the pressure. It has been shown that during this period the liquid flows in parallel lines without eddies or sinuosities. This has been shown by the injection of coloring matter in the liquid while flowing through a transparent tube.

As the pressure increases a point is finally reached at which quite suddenly the rate of flow commences to vary as the square root of the pressure, and simultaneously with this event the flow of the liquid is shown to break up into smoky convolutions caused by eddies and

sinuosities. This point is called the critical point, and marks the moment of change from one type of flow to the other.

The cause of the difference in behavior of the flow in respect to pressure is said to be due to the fact that in the non-sinuous flow the chief resistance to flow is caused by the viscosity of the liquid, while in the sinuous flow the chief resistance is that due to friction between the liquid and the walls of the tube. These two types of liquid flow were very beautifully pointed out and explained in 1883 by Prof. Osborne Reynolds, F.R.S., in a paper¹ entitled "An Investigation of the Circumstances Which Determine Whether Motion of Water Shall Be Direct or Sinuous, and of the Law of Resistance in Parallel Channels." This paper is well worth reading, and there will be found therein a logarithmic homologue of the "pressure-rate of flow" curve through a tube. The critical point is very interestingly indicated by the point at which the slope changes from 1 to 0.5.

A later paper on this same subject² by Professor Coker and Mr. Clement, 1903, communicated by Prof. Osborne Reynolds, F.R.S., entitled "An Experimental Determination of the Variation with Temperature of the Critical Velocity of Flow of Water in Pipes," is also of much interest.

Poiseuille,³ in 1842, developed from experimental data an empirical formula for sinuous or eddyless flow as follows:

$$v = \frac{\pi p r^4}{8lu}$$

Where p = pressure, r = inside radius of tube, l = length of tube, v = vel. of flow, u = coefficient of viscosity.

Later this empirical formula was derived by purely theoretical considerations.⁴

The coefficient of viscosity varies with the temperature. Poiseuille shows the general relation to be as follows:

$$N_t = \frac{N_o}{(1 + \alpha t + \beta t^2)}$$

Where N_o , α and β are constants for each liquid, t = temperature, and N_t the coefficient of viscosity at temperature t . For water $N_o = 0.017793$, $\alpha = 0.03580$, $\beta = 0.0002253$. For acetic acid $N_o = 0.016867$, $\alpha = 0.01826$, $\beta = 0.00008537$.

Slotte gives the relations as follows:

$$N_t = \frac{N_o}{(1 + \beta t)^n}$$

Where N_o , β and n are constants for each liquid.⁵

Still other empirical formulas showing the relation between coefficient of viscosity and temperature are in existence. Some of the constants apply only over limited ranges of temperature. Fig. 6 illustrates the effect of change in temperature upon the flow of water as computed by Poiseuille's rule given above. This shows that change in temperature has a very marked effect on the flow of liquids through porous masses, and is therefore of great importance in filtration.

Of the two types of flow there can be no doubt of the fact that the flow through a filter cake follows that of the non-sinuous or capillary type. This is indicated from the test by the behavior of the flow with respect to pressure.

Considerable investigation has been carried on in the past relative to the flow of water through porous masses

¹Phil. Trans. Royal Soc. of London.

²Phil. Trans. Royal Soc. of London V-LXXIV.

³Comptes Rendus, Vol. 15, 1842; "Mem. serv. Etr." 1846.

⁴For derivation of this formula see Elements of Physics, Nichols & Franklin, Vol. 1, p. 142; A Text Book of Practical Physics, Watson, 1906, p. 148.

⁵Physico-Chemical Tables, Castell Evans, Vol. 2, p. 629, 1911.

under the subject of underground flow. Darcy* in 1856 showed that the flow of water through soil varied as follows:

$$v = k \frac{p}{n}$$

Where v = vel. of ground water,
 p = pressure at end of soil column,
 n = length of column.
 k = a constant for different soils.

Hazen† in 1892 showed that:

$$v = cd^h \frac{h}{e} (0.70 - 0.03t)$$

Where v = vel. of flow,
 d = effective diameter of grain of sand,
 t = temperature,
 h = loss of head,
 e = thickness of sand,
 c = a constant.

Slichter* in 1897 showed that:

$$q = [1.0094] \frac{pd^2s}{\mu hk}$$

Where q = quantity in c.c.,

p = difference in pressure at ends of cylinder in centimeters at 4 deg. C.

d = diameter of soil grains in centimeters,

s = area of cross-section of the cylinder in square centimeters,

h = height of the column of sand in centimeters,

μ = coefficient of viscosity of the fluid,

k = a constant from Table II,

[1.0094] = the logarithm of a factor.

Table II is not here given, as the form of the equation is not affected thereby.

Franklin Kiram King* in a paper entitled "Principles and Conditions of the Movements of Ground Water," gave the results of a large number of tests showing the rate of flow of water through various porous mediums. In all cases the rate of flow varied approximately as the first power of the pressure.

All of these citations serve to verify the results of the test of the flow through a filter cake, and substantiate the conclusions already reached that the flow through a filter cake varies as the first power of the pressure.

EFFECT OF THICKNESS OF CAKE ON RATE OF FLOW

The effect on the rate of flow when the thickness of cake is varied, all other conditions being constant, can be inferred from Poiseuille's formula for capillary flow. This would indicate that the rate of flow varies inversely as the first power of the thickness. Darcy, Hazen, and Slichter have shown that this is true as far as flow through earth, sand and other porous mediums is concerned. It is safe to assume this is so as regards filter cakes also, as the thickness of cake corresponds to the length of tube in Poiseuille's formula.

At this point it is not practical to verify this assumption by actual test in a filter press, because the mathematical tools which will be disclosed later are not yet available. At first thought it would seem as though a test could be made to prove this statement by depositing a cake of a certain thickness and determining its rate of flow and then building up the cake to twice its original thickness and comparing its rate of flow with the first. This is not as simple as it seems, however, as, while it may be practical to deposit two cakes having a

thickness ratio of 1 to 2, it is quite another thing to secure two cakes having a resistance ratio of 1 to 2, because of the equivalent cake thickness of the cloth or filter base, and the effect upon the average thickness due to the grooves in the filter plate or filter support.

Later it will be shown how the above effects can be eliminated by mathematical means, but for the present the proposition that the rate of flow through a filter cake varies directly as the first power of the pressure and inversely as the first power of the thickness must be accepted as true.

PERMEABILITY

The above laws apply to flow of liquids through porous masses in general. To make the laws apply to a particular porous mass, another factor must be introduced. The writer can vouch for the fact that the flow through a 1-in. cake of Fuller's earth is quite different in amount from that obtained through a 1-in. cake of kieselguhr under similar conditions. If, however, the rate of flow under known conditions for each of the above substances be ascertained, the rate of flow under any other set of conditions for each one can be deduced from the general laws.

The factor which determines the rate of flow under known conditions may be called the permeability of the substance under those conditions. In order to place the permeabilities of different substances on a comparative basis it is necessary that the permeabilities be given for the same set of conditions. In other words, when the permeability of a certain porous mass is given, it should be understood that the value is that corresponding to a standard set of conditions—the same set to which all other permeabilities are referred.

The most convenient set of conditions to use as a standard in determining the permeability of porous masses are those which have values of unity. The permeability of a given substance may therefore be defined by the rate of flow through a cake 1-in. thick over an area of 1 sq. ft. when the pressure is 1 lb. per square inch. This greatly facilitates the reduction to flow under other conditions, it only being necessary to multiply the standard permeability of the substance by the area and pressure and divide by the thickness to obtain the new flow.

UNIT OF PERMEABILITY

A porous mass is said to have a permeability of one when unit pressure produces unit flow through unit thickness over unit area under standard conditions of temperature. In English units a porous mass is said to have a permeability of one when a pressure of 1 lb. per square inch produces a flow of 1 gal. per hour through a thickness of 1 in. over 1 sq. ft. of area at 68 deg. Fahr.

UNIT RESISTANCE

The reciprocal of the permeability of a porous mass is its resistance. It is easy to see that the resistance to flow of a porous mass varies inversely as its permeability. This being so, unit resistance may be arbitrarily defined as that resistance which a porous mass of unit permeability has. This unit is as yet unnamed.

EQUATION FOR FLOW THROUGH A POROUS MASS

The law governing the flow of liquids through a porous mass may now be expressed as follows:

$$\frac{dQ}{dt} = \frac{P}{R + t} \quad \text{..... (A)}$$

Where $\frac{dQ}{dt}$ = rate of flow of liquid with respect to time,

P = pressure of mixture,

R = resistance of material,

t = thickness of material.

*Les fontaines publiques de la ville de Dijon. Paris.

†Some Physical Properties of Sands and Gravels. Rept. Mass. State Board of Health, 1892, p. 541.

*Theoretical Investigation of the Motion of Ground Water.

19th An. Rep. U. S. G. S., Part 2, 1897-8.

19th An. rep. U. S. G. S., Part 2, 1897-8.

Second Process—Building Up of Cake

There are two things which determine what the thickness of cake produced by a given quantity of a mixture of a solid and a liquid shall be. These are, first, the cake-forming ability of the mixture, and, second, the per cent of solids in the mixture.

CAKE-FORMING ABILITY OF A MIXTURE

Mixtures of various substances do not necessarily have the same cake-forming abilities. For instance, 5 gal. of a 2 per cent by weight mixture of kieselguhr and water will, when filtered through 1 sq. ft. of filtering area, produce a cake much thicker than would 5 gal. of a 2 per cent by weight mixture of Fuller's earth and water when filtered through the same area.

RATE OF DEPOSITION

The cake-forming ability of a substance when mixed with a liquid may be called the rate of deposition of that substance. A substance is said to have a rate of deposition or a cake-forming ability of one when, under standard temperature conditions, a 1 per cent mixture of the substance with water produces a flow of 1 gal. per hour over an area of 1 sq. ft. when the pressure is 1 lb. per square inch. This unit is also unnamed.

All other things being equal, the thickness of cake produced varies inversely as the rate of deposition. That is to say, having equal quantities of mixtures of the same proportions, but of different kinds of solids, that one requiring the greatest amount of mixture to produce a 1-in. cake will, of course, form the thinnest cake over the same area.

PER CENT OF SOLIDS

If a given quantity of a mixture of a solid and a liquid produces a cake of a certain thickness over a square foot of filtering area, one may double the thickness of cake produced by doubling the amount of solids in the given mixture. In other words, the thickness of cake produced by a mixture varies directly as the per cent of solids therein.

LAWS GOVERNING THE BUILDING UP OF CAKE

The laws governing the thickness of cake may be stated as follows: The thickness per unit quantity of discharge varies inversely as the rate of deposition and directly as the per cent of solids. Expressed symbolically:

$$t = \frac{\%Q}{k} \dots \dots \dots (B)$$

Where t = thickness, % = per cent of solids, k = rate of deposition, Q = total quantity of discharge.

Fundamental Law of Filtration

Up to this point the two processes, flow through a porous mass and building up of cake, which constitute the phenomena of filtration, have each been investigated and their laws deduced. It now remains to combine these two sets of laws and thus derive the fundamental law of filtration.

The law of flow through a porous mass is as given in equation (A):

$$\frac{dQ}{dT} = \frac{P}{R_c}$$

In filtration the porous mass is composed of the deposited solids plus the filter base. If the resistance offered to flow by the filter base be designated by R_m , the rate of flow through the filtering medium would be:

$$\frac{dQ}{dT} = \frac{P}{R_c + R_m} \dots \dots \dots (C)$$

The law governing the building up of cake is given in equation (B):

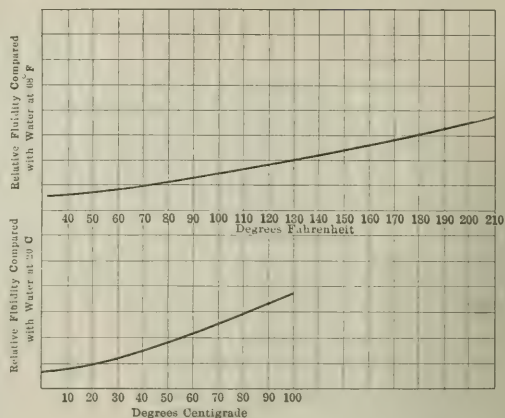


FIG. 6—EFFECT OF TEMPERATURE UPON THE FLOW OF WATER THROUGH A POROUS MASS

$$t = \frac{\%Q}{K}$$

Substituting this value of t in C:

$$\frac{dQ}{dT} = \frac{R_c'Q}{K} + \frac{R_m}{P}$$

$$\text{or } dT = \frac{R_c'Q}{PK} dQ + \frac{R_m}{P} dQ \dots \dots \dots (D)$$

In the above $\frac{dQ}{dT}$ is the rate of flow of filtrate. If the expression is integrated there results the expression of which $\frac{dQ}{dT}$ is the rate of change of discharge, Q , with respect to time, T . Such an expression is nothing more than the equation of the curve showing the relation between Q and T . In other words, it is the time-discharge curve from a filter or the fundamental law of filtration.

Integrating D between corresponding values of T and Q :

$$\int_0^T dT = \frac{R_c'}{PK} \int_0^Q Q dQ + \frac{R_m}{P} \int_0^Q dQ$$

$$\text{or } T = \frac{R_c'Q^2}{2PK} + \frac{R_mQ}{P} \dots \dots \dots (E)$$

In order to determine the value of Q alone, multiply both sides of E by $\frac{2PK}{R_c'}$ and add to both sides $\left(\frac{KR_m}{R_c'}\right)^2$.

This reduces E to:

$$Q = \sqrt{\frac{2PKT}{R_c'} + \left(\frac{KR_m}{R_c'}\right)^2} - \frac{KR_m}{R_c'} \dots \dots \dots (F)$$

Which is the fundamental law of filtration under standard conditions of temperature.

EFFECT OF TEMPERATURE

Temperature of a liquid effects its viscosity, and, as shown by Poiseuille's law, the rate of capillary flow is greatly influenced thereby.

To take this effect into consideration in the fundamental equation (F) it is only necessary to multiply the expression for Q by the amount representing the viscosity for the liquid under standard conditions and divide it by an expression giving the coefficient of viscosity for any other temperature. This must be so, because of the fact that the velocity of capillary flow

and therefore Q varies inversely as the coefficient of viscosity.

If Poiseuille's formula for relation between coefficient of viscosity and the temperature be used fundamental equation (E) becomes:

$$Q = \left[\sqrt{\frac{2PKT}{R'_c}} + \left(\frac{KK_m}{R'_c} \right)^2 - \frac{KK_m}{R'_c} \right] \frac{N_s}{1 + \alpha t_i + \beta t_i^2} \dots G$$

Where:

N_s = Coefficient of viscosity under standard conditions of temperature, say 68° F and $\frac{N_o}{1 + \alpha t_i + \beta t_i^2}$

Poiseuille's expression for the coefficient of viscosity at temperature t_i .

If the values for N_o , α and β at 20 deg. C. for water be inserted in G , the fundamental equation becomes:

$$Q = \left[\sqrt{\frac{2PKT}{R'_c}} + \left(\frac{KK_m}{R'_c} \right)^2 - \frac{KK_m}{R'_c} \right] \left(.556 + .0199t_i + .0001193t_i^2 \right)$$

Summarizing, it can be seen that filtration depends upon the following seven factors:

- P , the pressure
- T , the time of filtering
- K , the rate of deposition of the mixture
- R , the resistance of the material
- $\%$, the per cent of solids in the mixture
- R_m , the resistance of the filter base
- t_i , the temperature of the mixture

Two other factors may be added to this list, one, a factor modifying P , the pressure to allow for the squeezing together of non-rigid solids as the pressure increases, and another to take care of the influence of gravity through the agency of settling or sedimentation.

At first consideration it would appear as though the fundamental equation were too complicated to admit of practical use. Such, however, is actually not the case. It will subsequently be shown how this equation expressing the fundamental laws of filtration can be applied in the solution of practical filtration problems.

Batavia, Ill.

H. R. Conklin, Joplin, Mo., has issued an attractive little booklet describing the Conklin agitator, Conklin directed thickener, and Conklin bag filter.

Hydrostatic Instruments.—The Scientific Materials Company, Pittsburgh, Pa., has issued Efficiency Instrument Bulletin No. 4, describing various types of hydrostatic pressure and draft indicators and recorders. These instruments were formerly made in Germany, and are now made by this company.

Bromine.—The production of bromine in 1915 was 855,857 lb., valued at \$856,307, an increase of 278,866 lb. in quantity and of \$653,213 in value, according to the U. S. Geological Survey. The high price of bromine during 1915 and the first five months of 1916 was due, in part at least, to an unprecedentedly large demand from abroad. Bromine is made in connection with the manufacture of salt in the Saginaw Valley in Michigan, in the Ohio Valley in Ohio and West Virginia, and in the Kanawha Valley in West Virginia. In Michigan bromine has been marketed in the form of fine chemicals, but as a result of the great increase in demand caused by the war in Europe a large quantity is now being marketed as bromine itself. The bromine produced along the Ohio River, where salt and bromine occur naturally and where there is cheap rail and water transportation and an abundance of cheap coal and gas, has in part been exported to be made into fine chemicals. Here is an opportunity for the American chemist which should not be neglected.

Some Zinc-Lead Mills of California and Nevada

BY LEROY A. PALMER

It was only a few years ago that a zinc-lead ore presented a problem to the miner that he was unable to solve and that left him worse off than with a straight ore of either metal. Now, thanks to the advance made in the science of concentration, such an ore is no longer a disadvantage and may be so treated that all of the constituents yield a return to the operator.

In the following, brief mention will be made of three mills. Detailed description is not attempted for the reason that none of them involves any new principle, unless we except flotation, but all depend on the fundamentals of concentration.

The Needles Concentrator

The concentrator at Needles, Cal., Fig. 1, is one of the many plants of the United States Smelting Co. and follows the same general lines that this company first worked out successfully at Midvale, Utah. The ores treated are from the company's mine at Chloride, Ariz., and consist of galena, sphalerite, arsenopyrite and pyrite in a quartz gangue with some lime.

The ore is delivered at the mill in standard gauge, side-dump cars, which run onto a low trestle and are dumped to platforms beneath, Fig. 2. From these platforms the ore is shoveled to half-yard cars and teamed to a small bin below the ground level, from which it is delivered to a 30-in. conveyor 123 ft. long, which runs on an angle of 18 deg. and thus elevates the ore 38 ft. and delivers it to a hopper-bottomed bin. It is fed from this bin by means of a sector gate over an inch grizzly to a 12-in. x 18-in. Blake crusher set to 1 in. and making 240 r.p.m.

The crusher and grizzly deliver to a 14-in. elevator which dumps to two 3-ft. by 8-ft. trommels with $\frac{3}{8}$ -in. punched screens. The trommel oversize goes to a set of 16-in. by 36-in. rolls, making 70 r.p.m. The roll product is re-elevated to the trommel and the screen undersize goes to a 16-in. conveyor. This conveyor is 56 ft. long on an angle of 18 deg., so that the ore is elevated 17 ft. and delivered to the mill storage bin. From this bin it is fed by a plunger to a wet elevator, which delivers it at the top of the mill to the head of the screen line.

EXTENDED SYSTEM OF JIGGING AND TABLE CONCENTRATION

The primary screen line consists of three pairs of trommels with wire screens of $\frac{1}{4}$ in., $\frac{1}{8}$ in. and 1/16-in. mesh. The oversize of the trommels goes to eight three-compartment jigs of Harz type with plungers braced by steel straps from the eccentric stems. No



FIG. 1. NEEDLES CONCENTRATOR



FIG. 2—UNLOADING ORE AT NEEDLES MILL

jig product is rejected. The first compartment makes a lead-iron concentrate, the second lead-iron-zinc middling, the third zinc concentrate, while zinc middling discharges over the tailboard.

All middlings from the two coarser jigs go to a slope-bottom dewatering tank, one side of which is at an angle of 45 deg. and a few inches higher than the other. Lying against this sloping side is a 36-in. wheel with curved blades along the circumference, by means of which the middlings are scraped over the upper edge, while the slime overflows the opposite lower edge, passing over a screen for the removal of chips and thence to a Callow tank.

The dewatered middlings go to a set of wet rolls and are then elevated to the secondary screen line consisting of $\frac{1}{2}$ and 1/16-in. trommels. The oversize of both trommels is reground in a set of rolls which discharges to an elevator and back to the secondary screen line. The undersize of the 1/16-in. trommel goes to a jig similar to the others.

The middlings of the finer jigs, together with the undersize of the last primary trommel, go to settling boxes whose overflow passes to Callow tanks. The underflow is reground in a 4-ft. by 15-ft. tube-mill making 28 r.p.m. The tube discharge goes to an elevator by which it is raised to the Callow tanks.

The underflow of the Callow tanks goes to a three-compartment Harz jig and the overflow is laundered to a modified Calumet classifier, which feeds 15 Wilfley tables. These tables make five products: lead-iron concentrate, zinc concentrate with a small percentage of iron-zinc middling, tailing and slime. The concentrates go to hopper-bottomed boxes with 6-in. discharge plugs by which they are loaded direct to half-yard cars. The middlings are retreated on eight Wilfley tables, which make the same products as the first set. The tailings are retreated on three 6-ft. Johnston vanners, which make zinc concentrates and tailings, and the slimes are treated on three Deister tables, which make the same products as the vanners.

FLOTATION OF ZINC-BEARING SLIME

The Deister tailings and some of the original slime, amounting altogether to 20 tons per eight-hour shift, are retreated in a flotation plant for the further recovery of the zinc. This consists of three Callow cells. The pulp is agitated under 7 to 8-lb. air pressure in a small Pachuca tank in which it is mixed with oil and acid. The consumption of these materials in treating 20 tons per shift is 250 lb. of sulphuric acid and 10 to 16 lb. of oil, consisting of 75 per cent creosote and 25 per cent pine oil. The feed is distributed between two cells, the tailings of which are pumped to a third cell. No finishing cells are used, but the concentrates are

run direct to two Oliver filters for dewatering. The product of the flotation plant is zinc concentrate.

The mill has a capacity of from 200 to 225 tons per day. The concentration ratio on all products is 1.8 to 1, with one ton of lead concentrate to 4.2 tons of crude and one ton of zinc concentrate to 3.5 tons of crude. The zinc extraction is from 70 to 73 per cent and the total extraction is in excess of 90 per cent.

Yellow Pine Mill

The 100-ton mill of the Yellow Pine Mining Co. at Good Springs, Nev., is, strictly speaking, a separator rather than a concentrator. The ore is a high-grade lead-zinc material, and in the treatment at this plant no rejection is made, all products of the mill being shipped.

The ore is hauled from the mine in narrow-gage cars and dumped to the mill bins. It consists principally of lead carbonate and zinc carbonate and silicate. Sulphides are almost entirely absent as evidenced by the fact that the smelter returns on the lead concentrates show only 2 or 3 per cent sulphur.

From the mill bin the ore is fed to a short conveyor, on which the larger pieces of waste are sorted out. This conveyor dumps over a 1-in. grizzly and the oversize goes to an 8-in. by 16-in. roll-jaw crusher. Grizzly and rock breaker both discharge to a chain elevator, which dumps to the fine-ore bin.

The fine ore is delivered by a shaking feeder to a set of 16-in. by 36-in. Cornish rolls set to $\frac{1}{4}$ in. These discharge to a wet elevator, which raises the ore to the top of the mill, where it passes successively over $\frac{1}{4}$ -in. and $\frac{1}{8}$ -in. Impact screens. The screen oversize is treated on two 2-compartment Harz jigs, which make lead concentrates from the bed and hutch of the first compartment and middlings through the second compartment and over the tailboard. The middlings from the coarse jig are returned to the first set of rolls and those from the finer jig to a second set, both of which discharge to the elevator and to the Impact screens.

The undersize of the second screen goes to a five-compartment Richard's classifier, which makes six products, each of which goes to an Overstrom table. The tables make only two products, lead and zinc concentrates. The lead goes to tubs and the zinc, with all slime to settling bins beneath the table floor. The lead is shoveled to small cars, the zinc is drawn off through gates and the slime overflows to ponds from which it is shoveled out and shipped when a sufficient amount accumulates.

Under this system an extended run of 16,136.3 tons of crude ore assaying 10.2 per cent lead, 31.8 per cent zinc and 5.4 oz. silver produced 1521.085 tons of lead concentrate averaging 53.2 per cent lead, 13.75 per cent zinc and 28.1 oz. silver; 11,260.65 tons of zinc concentrate assaying 33.2 per cent zinc, 4.4 per cent lead and 2.5 oz. silver, and 2173.0 tons of slime averaging 7.3 per cent lead, 35.1 per cent zinc and 4.0 oz. silver; 833.4 tons of waste was removed by sorting. During 1915 milling cost was \$1.53 per ton.

Anchor Mill

The Anchor mill is characteristic of several dry mills that have been installed in the Good Springs district recently and uses a Stebbins table for concentration.

The ore is fed from the bin over a 1-in. grizzly to an 8-in. by 12-in. Dodge crusher set to $\frac{3}{4}$ in. The grizzly and crusher product go to a set of 14-in. by 30-in. rolls set to $\frac{1}{8}$ in. The roll product is elevated to an 8-ft. trommel with 8-mesh ton-cap screen, the oversize of which returns to the rolls and the undersize goes without further classification to a No. 6 Stebbins table with a capacity of two tons per hour.

PNEUMATIC CONCENTRATING TABLES USED

There are three products from this table: dust, which is removed by a fan and stacked behind the mill, lead concentrate, and either zinc concentrate or tailing, according to whether a zinc-lead or a lead ore is being treated. The lead concentrate is run to a bin by a conveyor belt and a screw removes the tailing or zinc product to another bin to be loaded to cars and wasted or shipped as the case may be.

The Stebbins table is made in seven different sizes, the extreme capacity of the largest size being 12 tons

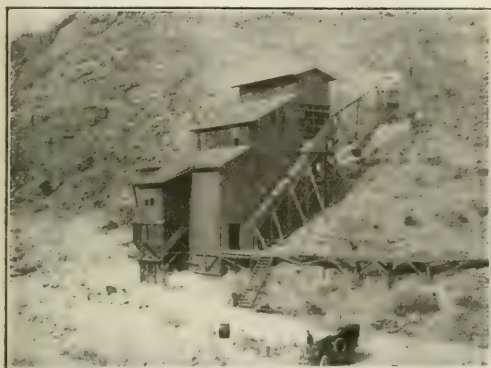


FIG. 3—ANCHOR MILL, GOODSPRING, NEV.

per hour. In general design and principle of action it is similar to the standard makes of riffle-deck water tables. The shape of the deck is similar to that of the Wilfley and it is provided with longitudinal riffles, all of which extend clear to the concentrate end.

The deck is of sheet metal with perforated slots which have a slanting lip over each so as to direct the air current through the ore layer at an angle instead of directly upwards. Beneath the deck is an air chamber into which a blower forces air, at a pressure varied to suit conditions, and from which it escapes through the slots in the deck. The table has a reciprocating motion and stratifies the ore as on a water table, simply using air as a medium instead of water.

All machinery—crusher, trommel, rolls, elevator and table—is tightly housed and the dust is drawn off by a 30-in. fan. While this ameliorates conditions, the mill is, at best, very dusty and employees wear respirators.

By this system a lead-zinc ore carrying 35 per cent lead and 24 per cent zinc is separated into a lead concentrate assaying 67 per cent and a zinc concentrate carrying 34 per cent zinc and 6 per cent lead.

On a straight lead ore the saving approximates 65 per cent. This saving appears low, but it should be borne in mind that at this mill the dust, which has about the same metal content as the original ore, is not treated and the process is comparable with a wet mill that does not treat its slimes.

San Francisco, Cal.

The Kansas Chemical Co., Hutchinson, Kan., has taken up water purification as a side line of its regular work. The development has been in charge of Leslie C. Hughes.

The American Alkali & Acid Co., Bradford, Pa., is planning an extension of its plant. The equipment at present being obtained for the manufacture of toluol, benzol, anthracene, naphthalene, creosote, phenol, hard pitch and ammonia.

Practical Methods for Testing Refractory Fire Brick*

BY C. E. NESBITT AND M. L. BELL

The use of refractory material in metallurgical operations is one which, as a rule, is given but very general consideration. The selection of a suitable refractory calls for a study, first, of the temperatures involved, and secondly, of the nature of the hot material and resulting slag to which the refractory will be exposed.

Refractories are generally used in form of bricks or blocks which are molded from materials in the plastic condition, then burned. The resulting product is a solid of sufficient mechanical strength to permit its use for various forms of construction.

The two most common raw materials for making refractory bricks are clay and a variety of silica called ganister. Other raw materials are gradually finding wider and more general use, but these two continue to be the important ones.

Clay and silica rock suitable for bricks are widely distributed, but nature has very largely determined their physical properties. Each of these materials has varying physical properties which may be taken advantage of and incorporated into the finished bricks, the quality of which is largely dependent on the methods employed in their manufacture.

In its simplest terms a furnace or heating chamber consists essentially of a shell of brick work sometimes bound together with a suitable framework of iron. Owing to various physical, chemical and mechanical operations which take place in the furnace, the refractory must meet certain demands to give a satisfactory life. No brick can be expected to be best in all physical properties, and it becomes necessary to select the brick which is best suited to withstand that particular condition imposed by the furnace. It may be that the brick will have to withstand the abrasive action of heavy, hard materials, the sudden fluctuation of temperature, the corrosive action of slag, or the action of load while at high temperatures. These and similar points should be considered, their relative importance determined, and the brick chosen should be the one best suited to resist that particular condition.

In the iron and steel industry the blast furnace is one of the most important types of furnaces. In simple terms it is a hollow steel cylinder, approximately 100 ft. high and some 28 to 30 ft. in diameter, lined with fire brick. In a furnace of 500-tons capacity about 1900 tons of ore, limestone and coke are used every 24 hours. These materials, often wet or frozen, are fed in at the top and fall on the materials already in the furnace or roll over against the walls. Since this material must pass slowly through the furnace, the wear of the lining is extremely heavy. The temperature at the top of a blast furnace is low, but as the charge descends the temperature increases until the fusion zone is reached. In this zone the hard material composing the charge becomes a pasty mass which ultimately is melted, and the brick work then has to withstand molten iron and slag rather than abrasion or impact.

No blast furnace is complete without its battery of stoves in which no metallurgical operations take place. The object of the stove is to absorb heat rapidly and then as quickly give it up. Here a brick must withstand sudden thermal changes, abrasion, slagging, due to the dust carried by the burning gas, and possess good heat-absorbing qualities.

In one of the processes of converting pig iron into steel a basic open-hearth furnace is used. This furnace

*A paper presented at the Atlantic City meeting, June, 1916, of the American Society for Testing Materials.

is built up largely of silica brick, although the hearth is made up of basic materials because of the basic character of the slag, while the regenerators are of fire brick. Silica bricks are very sensitive to thermal changes, but owing to their infusibility and their ability to withstand heavy loads when highly heated, they are used almost without exception in open-hearth practice. Any variation in manufacture of material which will tend to decrease their sensitiveness to heat changes, without sacrifice to their other good qualities, will directly increase the life of the furnace.

In soaking pits, heating furnaces, annealing furnaces, mixers, ladles, etc., the temperatures are not as high as in the open-hearth furnace; the brick work here has mainly to withstand the action of the molten metal, iron scale, or slag.

A general review of the conditions imposed on fire brick as used about iron and steel plants has pointed out two general conclusions: (1) the life of a furnace is determined by the life of its brick work, and (2) different furnaces demand different physical properties in the brick used.

DESCRIPTION OF TESTS

A great many investigators have attacked the problem of refractories, the work having been done mainly from the standpoint of the inherent physical properties of the raw materials. The results are of high technical excellence and have been of value. In the majority of cases, however, the tests have not been applicable to brick as received by the consumer. He could not go out to his stock, select several bricks and quickly determine their value for his particular purpose.

With this idea in mind each of the various conditions where fire brick are used was studied to determine the cause of failure. The next step was to imitate actual conditions of service in the laboratory. This meant that tests must be employed which were very severe, producing in a short time what in actual service might require months, or even years to accomplish. To test brick cold and say that the result of the cold test was a measure of the performance when hot did not seem justifiable. Another point was to make the tests such that the work could be done on the brick as received, and not on bricks prepared for the test.

In the study of service conditions, attention was first

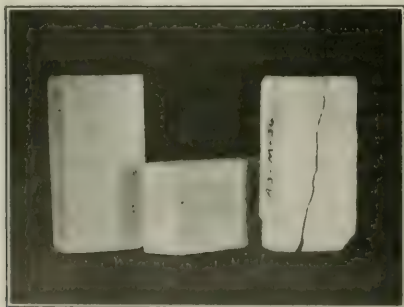


FIG. 1 IMPACT TESTS, ILLUSTRATING CHARACTERISTIC FRACTURES

directed to the top of the blast furnace. The average temperature at the top is about 260° C. The charging of a furnace is a nearly continuous operation, the material charged falling on the large bell, which, when lowered allows the material, often wet or frozen, to slide off the bell and strike the walls of the furnace. Immediately the charge starts slipping and grinding its way slowly downward past the brick in the wall. These

conditions required tests that would imitate impact, abrasion and spalling.

Impact Test.—An impact test was first considered. The rattler and other similar tests were studied, but it was finally decided that some kind of a drop test would be the most practical, and would most nearly approach service conditions. After trying many shapes and sizes of falling weights it was finally decided to use a steel

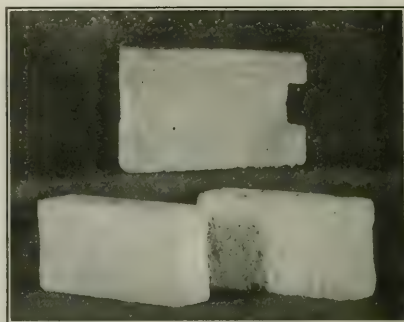


FIG. 2—ABRASION TESTS, SHOWING DIFFERENCE IN DEPTHS OF CUTS IN UPPER BRICK

ball 2½ in. in diameter. The brick was heated to 260° C. and the ball allowed to drop on the end of the brick from a height of 2 in., then 4 in. and so on, until the brick broke. The height to which it was necessary to raise the ball to cause fracture of the brick represents a particular quality, namely, resistance to impact.

The comparative strengths of brick to resist impact at ordinary temperatures and at slightly elevated temperatures is interesting. A brick heated to 260° C. and tested was 20 per cent weaker than a brick of the same brand tested at 20° C., and 40 per cent weaker when tested at 540° C. (Fig. 1).

Abrasion Test.—In developing an abrasion test it was



FIG. 3—SLAG PENETRATION AND ABRASION ON SILICA BRICK—PORTION OF AN 18-IN BULKHEAD

found that others had abraded brick in the cold by means of an emery wheel. This idea was modified so as to test the brick while hot. A temperature of 260° C. was adopted for top-wall and pipe brick, and 1350° C. for all others. The reason for choosing 1350° C. for the high temperature was that (1) it is a comparatively easy temperature to reach with a test furnace, and (2) while it might not represent the highest temperature in the

furnace, it is above the melting point of cast iron, and is applicable to all high-temperature furnaces used about iron and steel plants.

The brick to be tested was heated to 1350° C. and then pressed against a carborundum wheel, pressure and time being constant. When the brick became cold the depth of cut was measured and the result reported as linear inches abraded in 5 minutes. This test developed the interesting fact that bricks are not always the same at both ends, for it was found that sometimes there may be 10 to 20 times as much abrasion at one end as the other (Figs. 2, 3, 4 and 5).

Spalling Test.—Spalling was next studied. In brick work such a condition is usually the result of thermal changes, often accelerated by mechanical pinching. In actual service only one surface, generally the end or side of the brick, is exposed to the direct action of heat.

After trying various tests it was decided to place the brick to be tested in the wall of the furnace so that only one end was exposed. The testing temperature was

confined by the use of kaolin rings, but both tests were unsatisfactory. To confine a comparatively large portion of slag to any one portion of the brick it became necessary to drill a cavity in the brick and place the slag therein. Experiments were made to determine the effect of fineness of the slag, time of exposure to heat, and the effect of destroying the surface texture by drilling. To measure the slag penetration the brick is cut through the pockets of the slag and the area of brick penetrated by the slag measured with a planimeter (Figs. 8, 9 and 10).

Compression Test.—The ability of brick work to stand up under loads when highly heated is of great importance. A comparative test consisting of a modified Brinell ball test was used by heating the brick to 1350° C., removing from the furnace and then forcing a 2½-in. steel ball into the brick under a pressure of 1600 lb. The depth of the impression was then measured when cold (Figs. 11 and 12).

Expansion, Contraction and Fusibility.—These are important qualities of fire brick. For these tests the

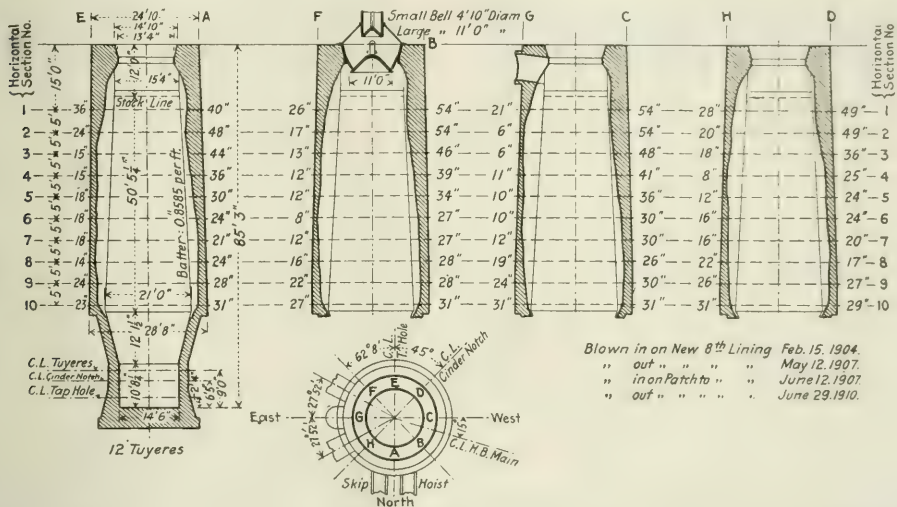


FIG. 4—VERTICAL LINES OF EROSION ON A BLAST FURNACE AFTER SIX YEARS' SERVICE—UNIFORM WEARING

NOTE.—The letters E, A, etc., represent vertical sections taken on the diameters shown in the plan; the figures 1, 2, 3, etc., shown at the left and right, designate the horizontal sections, which are shown in Fig. 5. The figures on the outside of the vertical sections represent the thickness of the brick lining remaining at these points.

1350° C., and after a series of experiments as to the most satisfactory time for heating, one hour was decided upon, with 25 minutes' cooling in a blast of air. To produce a measurable spall at least 30 operations of heating and cooling were required. This was too long, and it was decided to increase the severity of the test by cooling in water for 3 minutes, and so hasten the spalling. A series of tests determined that cooling in water was three times as effective as air cooling. The number of operations was accordingly cut down to ten. The amount of spalling is reported as the percentage loss in weight. This test applies only to fire brick (Figs. 6 and 7).

Slagging Test.—The failure of brick work due to the corrosive action of slags is more prevalent than any other cause. Not only is the slag action marked in blast furnaces but also in open hearths, cupolas, and heating furnaces, and to a lesser degree in mixers, ladles, fireboxes, etc.

During the development of a slag test the slag was first placed on the surface of the brick. It was next

usual methods were followed, and they need not be mentioned further at present (Figs. 13 and 14).

RESULTS OF TESTS

As a result of a large number of tests following the methods which have been outlined, it was found that fire bricks tended to group themselves according to density. In general, bricks of high density, all other factors being equal, have the most desirable qualities, namely, least abrasion, good resistance to slag and least compression. Spalling is very slightly increased, but not to a dangerous extent if bricks are not over-burned.

As a measure of density, the apparent specific gravity is used—obtained by weighing and measuring the brick and not by suspension, as is usually done. Results show that various makes of brick have characteristic values for apparent specific gravity and that the method of manufacture greatly influences the density. A series of preliminary experiments had shown the importance of pressure and moisture in producing a dense brick, and this test was followed up by a more elaborate series. A

TABLE I—RESULTS OF TESTS ON FIRE BRICK OF VARYING MOISTURE CONTENT

Properties Considered	PERCENTAGE OF MOISTURE						
	4	6	7	8.5	10	12	
Apparent specific gravity	2.11	2.17	2.19	2.16	2.10	2.06	
Compression at 1350 deg. C., depth of impression, in.	0.49	0.44	0.43	0.51	0.53	0.57	
Expansion per foot of length at 1350 deg. C., in.	0.064	0.064	0.045	0.045	0.049	0.050	
Impact at 260 deg. C., height of drop, in.	18	33	45	35	31	30	
Abrasion at 1350 deg. C., in five minutes, in.	0.024	0.008	0.012	0.016	0.028	0.020	
Blast-furnace slag, sq. in.	0.37	0.30	0.24	0.28	0.43	0.36	
Open-hearth slag, sq. in.	0.82	0.48	0.58	0.66	0.66	0.74	
Heating-furnace slag, sq. in.	1.65	0.35	0.29	0.42	0.42	1.26	

standard fire-clay mixture was used, in which the moisture was varied from 4 to 12 per cent, and all bricks were pressed at 2000 lb. per sq. in., then burned in a regular kiln. Results of tests applied on this series are shown in Table I and Fig. 15.

TABLE II—RESULTS OF TESTS ON A HIGH-PRESSURE, LOW-MOISTURE BRICK AND A HAND-MADE, REPPRESSED, ORDINARY-MOISTURE BRICK

Properties Considered	KIND OF BRICK	
	Pressure of 1500 Lb. per Sq. In., Moisture, 7 per Cent	Hand Made, Repressed, Ordinary Moisture
Compression at 1350 deg. C., depth of impression, in.	0.29	0.55
Expansion per foot of length at 1350 deg. C., in.	0.062	0.059
Impact at 260 deg. C., height of drop, in.	45	28
Abrasion at 1350 deg. C., in five minutes, in.	0.02	0.04
Spalling, loss, per cent.	9.4	10.6
Slag penetration, (Blast-furnace slag, sq. in.)	0.27	0.56
(Heating-furnace slag, sq. in.)	0.26	0.67

Conclusions can only be drawn when all conditions except brick quality are the same.

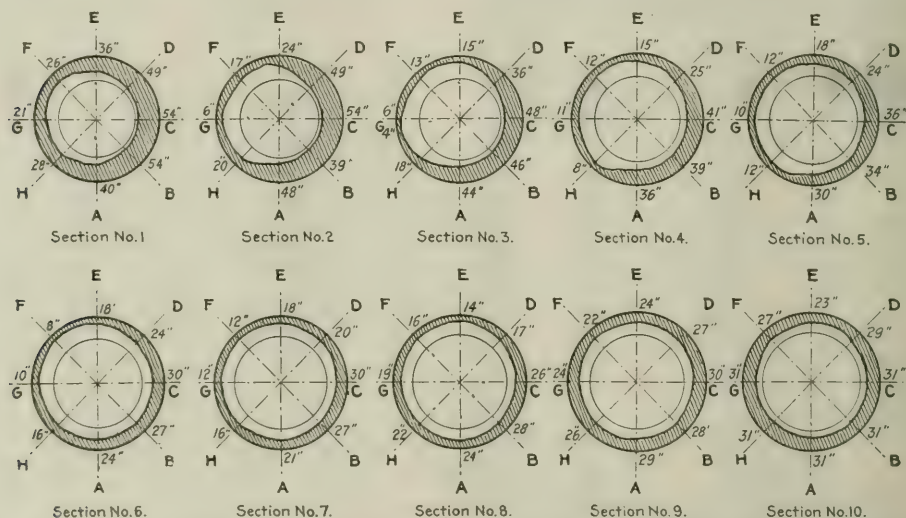


FIG. 5—HORIZONTAL LINES OF EROSION ON A BLAST FURNACE AFTER SIX YEARS' SERVICE—UNIFORM WEARING

NOTE.—The letters at the ends of a diameter refer to the corresponding section indicated in the plan view of Fig. 4. The figures at the ends of a diameter indicate the thickness of the brick remaining at the ends of that diameter. For example: Horizontal section No. 1 shows thicknesses at the ends of the diameter EA equal to 36 and 40 in.; at the ends of diameter FB, 26 and 54 in., etc. These figures will also be found along the horizontal line of section No. 1, in Fig. 4.

Power-pressing a brick during manufacture up to 1500 lb. per sq. in. has been found to materially improve the quality of most fire brick; beyond that figure very little improvement is made. A comparison of tests on a high-pressure, low-moisture brick and a hand-made, repressed, ordinary-moisture brick, both brick of the same mixture, is given in Table II.

The laboratory methods suggested have been developed mainly with reference to bricks to be used in iron and steel plants. When modified they are applicable to almost any condition of service to which the bricks will be subjected. If a brick is to be used in a boiler setting, copper or lead smelter, calcining or roasting furnaces, the test should imitate these conditions, in order that the results be comparative. Conditions of service must be studied to learn what is demanded of a brick.

When a laboratory test has been developed it must be confirmed by actual service tests. To compare the life of two similar furnaces built of different materials, or even the same furnace built of different materials at different times, does not necessarily mean that the material showing the longest life is the better, since the operating conditions may have been decidedly different.

To derive the greatest benefit the consumer and manufacturer must work together. The manufacturer's interest must not cease with the shipment of his product. The consumer should provide all reasonable facilities for the manufacturer to study his product in actual service. It is only by such co-operation or exchange of information that the best results can be obtained. A more detailed description of apparatus and methods is appended.

APPENDIX

Methods of Testing Refractory Fire Brick¹

IMPACT TEST

Construction of Apparatus.—The machine for determining the resistance to impact consists of two vertical uprights 15 ft. high, supporting two vertical and parallel 1½-in. angle irons. The angle irons are placed so that their inclosed angles face each other and are braced 3½ in. apart measured from the inside of the

¹At the present time the machines and apparatus here described are in a state of development, and while they have been standardized for the test, the machines and methods themselves are not necessarily final.

angles so as to allow a ball $2\frac{1}{2}$ in. in diameter to fall freely between them, the sidewise movement of the ball not to exceed $\frac{1}{4}$ in. These angle irons are adjusted so that bricks of different heights may be placed under them, and are marked, beginning at the lower ends, so as to clearly designate successive heights of 2 in. The test specimen is placed directly below the angle irons on a steel block of sufficient size to give a solid foundation. The upper face of the block is perfectly smooth and at

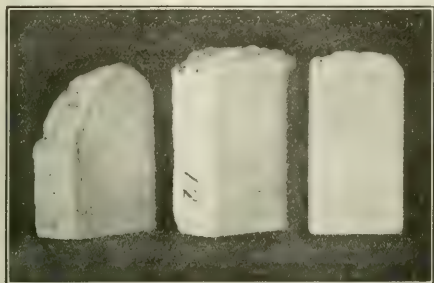


FIG. 6—CHARACTERISTIC SPALLING-TEST SPECIMENS

right angles to the angle irons. The block is $6\frac{1}{2}$ by 15 by 12 in., and weighs 332 lb. The falling weight is a steel ball $2\frac{1}{2}$ in. in diameter weighing 2.34 lb.

Operation of Test.—The brick to be tested is first carefully inspected, and, if necessary, ground on a carborundum wheel so that it sets firmly on one of its ends. On the other end of the brick the diagonals are then drawn to locate the center. The brick is now placed in a cold furnace and heated at a uniform rate from atmospheric temperature to 260° C., so that at least one hour is required to reach the final temperature. The final temperature (260° C.) is maintained for not less than three hours.

The brick is now ready for the test and is placed on

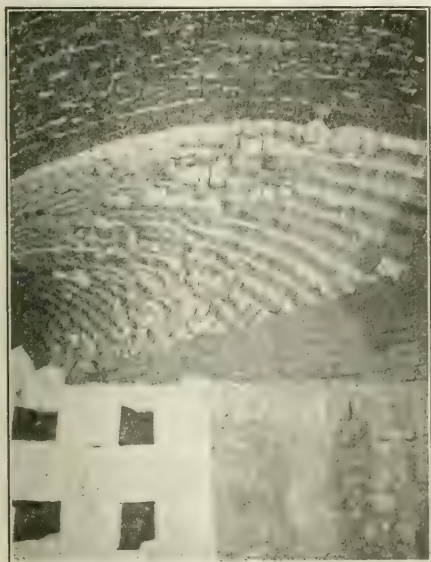


FIG. 7—SPALLING IN ROOF OF AIR FLUE OF OPEN-HEARTH FURNACE

(Note similarity between actual and test spalling)

the steel block, so that the ball between the angle irons touches the brick at its marked center. Iron blocks are placed around the brick until they are nearly level with the top of it, to prevent sidewise movement, but the brick is not wedged. The ball is now dropped from a pair of tongs on the end of the brick at successively increasing heights of 2 in. until the brick fractures. Any fracture radiating 1 in. or more from the point of contact of the ball is considered a fracture, and the distance in inches of the last drop is the result of the test. If the ball is allowed to drop again from the last height the brick

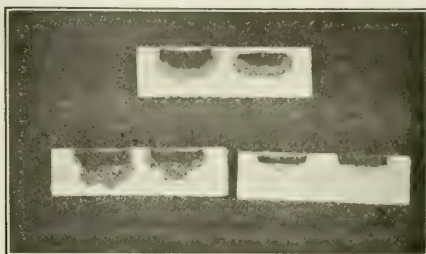


FIG. 8—CHARACTERISTIC SLAG-TEST SPECIMENS

gives off a dead or broken sound. The clear ring of a sound brick has disappeared.

COMPRESSION TEST

Construction of Apparatus.—The machine for determining the resistance to compression is a modified Brinell ball testing machine and consists of a 4-in. I-beam 10 ft. long and weighing 75 lb., so arranged as to act as a second-class lever arm; that is, one end is the fulcrum and at the other end the weight is applied so as to produce the compression on the brick placed 6 in. from the fulcrum. All bearings are knife-edged. The fulcrum end of the bar is mounted between two vertical uprights, 10-in. channel irons and so arranged that the height of the fulcrum may be adjusted by a hand wheel to suit bricks of varying thickness. Six inches from the fulcrum towards the weighted end of the bar a spherical

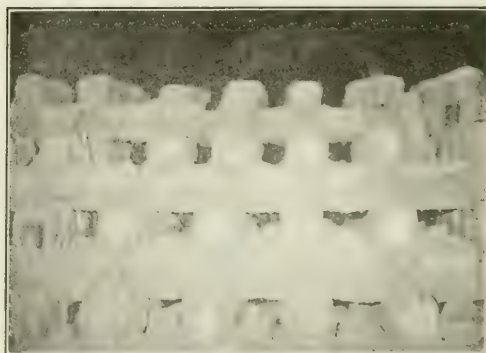


FIG. 9—CHECKERS IN GAS CHAMBER OF OPEN-HEARTH FURNACE, SHOWING SLAGGING

depression marks the location of the ball. The ball is a steel ball $2\frac{1}{2}$ in. in diameter weighing 2.34 lb. The brick to be tested rests on a solid foundation directly below the depression. The bar alone produces a pressure of 850 lb. on the ball, and the balance of the weight is added at a uniform rate of 25 lb. per second by means of dry sand, which flows from a hopper into a bucket at-

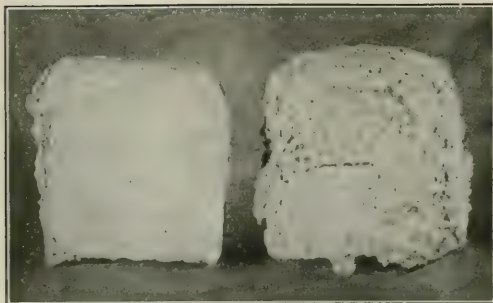


FIG. 10—INDIVIDUAL CHECKERS FROM GAS CHAMBER OF OPEN-HEARTH FURNACE, SHOWING SLAG PENETRATION

tached to the end of the bar. Bar and sand together produce a total load on the ball of 1600 lb.

Operation of Test.—The brick to be tested is placed in a cold furnace and heated slowly to 1350° C. The heating as a convenience is done over night at a uniform rate not to exceed 260° C. per hour. Total time of heating should in no case be less than 6 hours. The brick before testing should be maintained at 1350° C. for not less than 3 hours.

The brick is now removed from the furnace and placed flat on the foundation beneath the bar, and the bar lowered so that when the ball is in position in the depression it is also in contact with the center of the upper surface of the brick. The weighted end of the bar is then gently released and the flow of sand immediately started. The time required to remove the brick from the furnace and apply the load is less than one minute. The pressure is maintained for five minutes, starting from the time the bar is released. The brick is then removed from the machine and allowed to cool. When cold the depth of penetration produced by the ball is measured by placing centrally over the depression a flat rectangular plate $3\frac{1}{2}$ in. sq. ($\frac{1}{4}$ in. thick), at the center of which is mounted at right angles to it a Brown & Sharpe micrometer depth gage. The lower end of the stem of the micrometer is rounded so that it has the same radius as the $2\frac{1}{2}$ -in. ball. The depth at the center of the depression is measured to 0.001 in.

ABRASION TEST

Construction of Apparatus.—The abrasion testing machine consists of a carborundum wheel mounted on a suitable stand and revolving vertically. In front of the wheel and resting on the stand is an L-shaped plate $6\frac{1}{2}$ by 16 by $\frac{1}{4}$ in. resting on roller bearings and forced

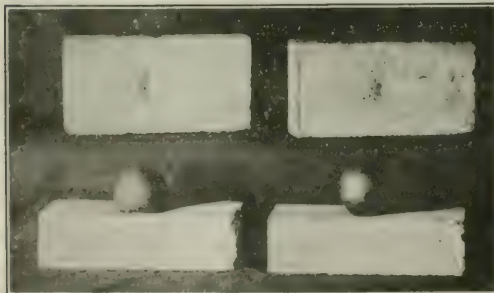


FIG. 11—CHARACTERISTIC COMPRESSION-TEST SPECIMENS, SHOWING DEPTH OF BALL AND CORRESPONDING IMPRESSIONS

towards the wheel by means of a right-angle lever arm, and suspended weights. The upper surface of this plate is $1\frac{1}{4}$ in. below the horizontal radial line drawn from the center of wheel. All points of contact on the lever arm are knife-edged and friction is reduced to a minimum. The carborundum wheel is 18 in. in diameter, has a 2-in. face and $1\frac{1}{2}$ -in. center hole, and is purchased from the Carborundum Company, grit 16; grade J; bond G-5. The wheel is motor driven and has a surface speed of 1640 ft. per minute and is to be redressed when the corners wear away $\frac{1}{4}$ in. of their original radius, or as soon as the face ceases to be at right angles to the side of the wheel. The pressure of the brick against the



FIG. 12—SPALLING, ACCELERATED BY COMPRESSION, OF ENTIRE CORNER OF AIR FLUE IN OPEN-HEARTH FURNACE

wheel is 10 lb. per sq. in. of brick in contact with the wheel, excluding the pressure required to move the brick.

Operation of Test.—The brick before testing is ground cold to a uniform thickness of 2.35 in. for $2\frac{1}{2}$ in. brick, and for 2.80 in. for a 3-in. brick, and the ends ground so that the testing wheel cuts through this thickness. The depth of this preliminary cut is measured at its center, using the rectangular plate described under the compression test. The brick prepared for test is heated

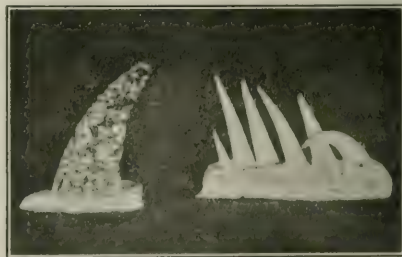


FIG. 13—CHARACTERISTIC SOFTENING-TEST SPECIMENS

the same as under the compression test, except in the case of top-wall and pipe brick, which are heated the same as for the impact test.

The brick is then removed from the furnace, placed flat on the plate in front of the wheel so that the wheel enters the preliminary cut, and is then abraded for five minutes. The time is taken with a stop-watch. In the case of soft brick, which abrade very rapidly, the test is run for a fraction of the period, and then calculated

to the five-minute period. The brick is now returned to the furnace and reheated for not less than one hour. The test is then repeated on the other end of the brick. When cold the depth of cut on both ends is measured, and the difference between the preliminary and the final cuts is the result reported.

SPALLING TEST

Operation of Test.—Preparatory to the test the fur-

minutes. The bricks are then removed and allowed to dry for three minutes in air. To indicate three-minute periods a stop-watch is used. The bricks are then placed in the doorway of the furnace as before, and the operation repeated for a total number of ten times. The bricks are now dried at 100° C. for at least five hours, and all particles which can be easily broken off with the fingers removed. The bricks are then weighed and the percentage of loss calculated from the original weight.

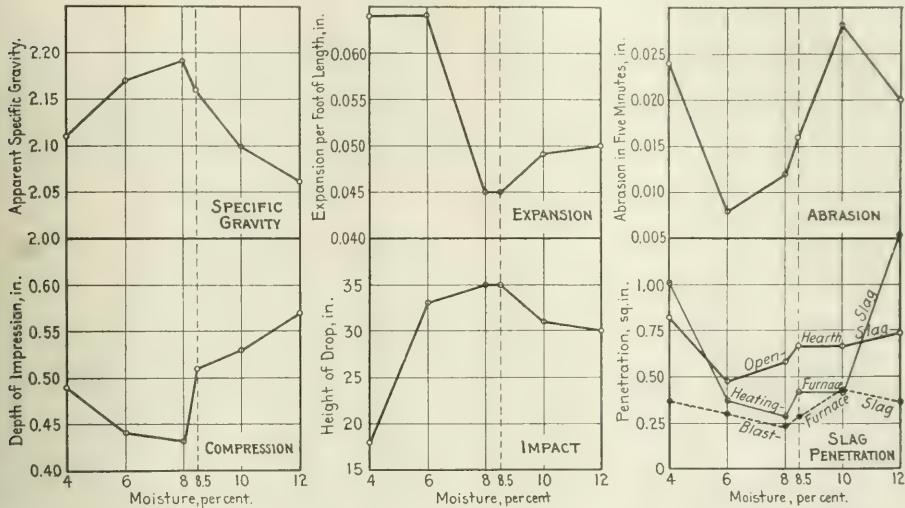


FIG. 15—INFLUENCE OF WATER USED IN MANUFACTURE ON PHYSICAL PROPERTIES OF FIRE BRICK

nace is heated to 1350° C. and held at this temperature for about one hour. The bricks to be tested are dried at 100° C. for at least five hours, weighed, and then placed in the doorway of the furnace, their ends flush with the inside of the wall. In case a sufficient number of bricks are not being tested to entirely fill the doorway, the remainder of the space is filled in with other bricks to insure heating the ends only. The bricks are now heated for one hour and plunged separately into 2 gal. of water at 20° C. to a depth of 4 in. and held there for three

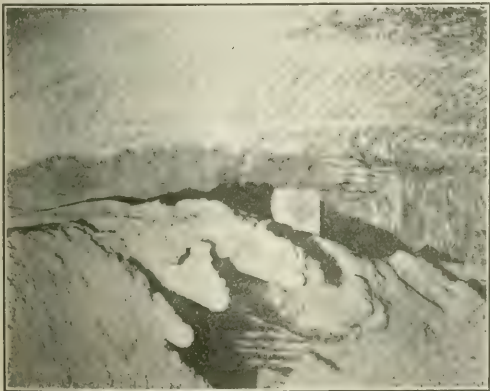


FIG. 14—GAS AND AIR PORTS INSIDE OPEN-HEARTH FURNACE
(Note slagged condition of walls and roof, and total disappearance of brick around water cooler in foreground.)

SLAGGING TEST

Operation of Test.—In preparing the sample for the slagging test, the 9 by 4½-in. unbranded side of the brick is bisected by a line across the narrow dimension and diagonals drawn on each half. At each intersection of the diagonals a circular cavity is drilled 2½ in. in diameter and ½ in. deep at the sides. The drills are 5/16 in. thick and 2½ in. wide, measured diagonally across opposite corners, while the point of the drill includes an angle of 150 deg. A template is made of 3 16-in. sheet steel to insure that all drills are ground properly. To insure a standard depth of cavity, two in-

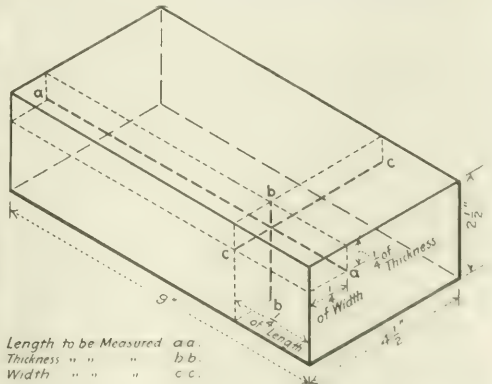


FIG. 16—AXIS ALONG WHICH MEASUREMENTS ARE TAKEN IN DETERMINING THE SIZE OF A BRICK

verted U-shaped pieces of metal are clamped to each drill when in use and adjusted so that drill cannot enter the hole more than $\frac{1}{2}$ in., measured on the side of the drill. The cross-section of the cavity passing through the deepest point has an area of 1.7 sq. in., and is checked up for size and depth by a template. The pressure used in drilling must not be so severe as to partially crack the brick.

After the cavities have been drilled and cleaned of loose material the bricks are placed level in a cold furnace and heated as in the compression test. When 1350° C. is reached 35 g. of standard blast-furnace slag are placed, by means of a long rod with a spoon-shaped end, in one cavity, and 35 g. of standard heating-furnace slag in the other cavity. The slags used shall have approximately the following analysis and melting points:

	Blast-Furnace Slag	Heating-Furnace Slag
Silica (SiO ₂), per cent.	38.0	35.0
Iron (Fe), per cent.	1.5	44.0
Manganese (Mn), per cent.	1.0	0.5
Alumina (Al ₂ O ₃), per cent.	14.5	6.0
Lime (CaO), per cent.	42.0	1.5
Magnesia (MgO), per cent.	2-0	0.5
Sulphur (S), per cent.	1.0	.....
Melting point, deg. Cent.	1260	1260

The fineness of the slag is such as to pass a 40-mesh sieve. The bricks are kept at a temperature of 1350° C. for two hours after the slag is added, at the end of which time the furnace is allowed to cool, or the bricks may be removed from the furnace and allowed to cool in air. The bricks when cold are sawed lengthwise at a right angle to the unbranded side, so that one side of the cutting wheel cuts through the center of the drilled cavity, and this area of slag penetration, together with the cavity, is measured with a planimeter. The area of the original cavity is subtracted, giving the result in square inches of slag penetration. The wheel used for sawing the brick is a carborundum wheel 12 in. in diameter; $\frac{1}{8}$ in. thick; $1\frac{1}{2}$ -in. center hole; grit 16; bond NCH.

SOFTENING TEST

Operation of Test.—The test specimens for determining the softening temperature are cut by means of the saw used in slagging test from the corner of the brick, in the shape of a triangular pyramid similar to that of a Seger cone. They are 3 in. high, and the base should not be less than 1 in. on the side. The test specimen, together with a series of Seger cones, is set in some good refractory material which will not flux with the sample. The series of cones used includes numbers both below and above the cone at which the sample is supposed to soften. The whole is placed in a gas-fired furnace and heated at a uniform rate, not to exceed 600° C. per hour. The softening temperature is considered that at which the specimen either bends double, sags, or puffs out of shape and is determined by Seger cones.

EXPANSION AND CONTRACTION

Construction of Apparatus.—The machine used for the measurement of expansion and contraction consists of a micrometer mounted on a steel post, which in turn is mounted on a steel plate 24 by 6 by $\frac{1}{2}$ in. To the stem of the micrometer is fastened a steel disk 1 in. in diameter and $\frac{1}{8}$ in. thick. In line with the micrometer is a second steel post on which is mounted a $\frac{1}{4}$ -in. sliding steel rod with a similar circular disk, as with the micrometer. The rod can be adjusted so as to determine measurements up to 14 in. To insure that this rod is properly set, standard bars 3, 5, 9, 11 and 13 in. long are used.

Operation of Test.—In preparing the brick for the test

the ends of the brick are ground so as to be parallel to each other at right angles to the sides. The length is then measured cold. The brick is then heated as in the compression test—or as for the impact test in the case of top-wall and pile brick—removed from the furnace and measured hot. The removing from the furnace and measuring usually requires about 30 seconds. The result is calculated to inches per linear foot.

SIZE

Operation of Test.—The size is determined by the use of the micrometer described under expansion and contraction. All measurements are made while the brick is at atmospheric temperature. Small particles of sand, clay or foreign matter adhering to the brick are removed before measuring. The locations for taking the measurements are shown in Fig. 16. If the bricks are of a different size than a standard 9-in. brick, the measurements are made in the same way, but at a point of one-fourth of their respective dimensions.

Synopsis of Recent Chemical and Metallurgical Literature

Gold and Silver

Oxidation of Soluble Sulphides in Cyanide Solutions.—In the course of experimental work on leaching roasted ore with cyanide solution, H. R. EDMANDS gave attention to solutions foul with soluble sulphides and the oxidation of those compounds. His results are recorded in the April *Journal* of the Chamber of Mines of Western Australia. The general impression has been that soluble compounds were very unstable, disappearing on decantation from one vessel to another, if they are not already precipitated by the zinc always present in mill solutions. Results showed that their proneness to oxidation has been overestimated and that the presence or absence of protective alkalinity has little effect on their oxidation, but that soluble carbonates tend to hasten oxidation. A more effective oxidation occurs in the leaching vats where, after draining, a strong oxidizing effect is given by included air, assisted by the presence of ferric oxide.

Effect of Lead Salts in Cyanide Treatment.—The same author gives results of solvent activity tests, using various solutions on pure gold and roasted ore. For the pure gold tests he used a plate of metal of 9 sq. cm. total area, and agitated it for 16 hours in a stoppered bottle of 344 cc. capacity, with 200 cc. of the solution to be tested, thus leaving 144 cc. of air containing about 0.038 g. oxygen, or sufficient for the oxidation of 945.6 mg. gold. In addition the effect of adding lead acetate to solutions containing soluble sulphides was determined and from this it appears that if the precipitated sulphide be removed by filtration a considerable increase in solvent activity ensues, but that the presence of PbS renders solutions carrying any protective alkalinity almost incapable of dissolving gold, which power is only imperfectly restored by neutralizing the protective alkalinity.

Experiments made on the roasted ore showed that the addition of CaO improved extraction; adding lead acetate in addition to CaO gave a further improvement; but the best extractions were obtained by adding acetate and omitting lime, at a cost, however, of greater cyanide consumption.

It should be noted that in these tests no soluble sulphides were detected either before or after treatment.

Somewhat different results were obtained by two following tests, in which roasted ore was agitated with solution foul with soluble sulphides.

A. Solution contained 0.0036 per cent soluble sulphides in terms of K₂S, 8 lb. CaO added per ton ore, and excess air present.

	Residue
(1) Amount acetate added, twice that required to precipitate all K ₂ S.....	178. 6d.
(2) Acetate sufficient to precipitate all K ₂ S, no excess.....	108. 6d.
(3) No acetate used.....	88. 6d.

B. Solution contained 0.0023 per cent soluble sulphides, in terms of K₂S, no CaO added, but solution on already contained 0.019 per cent CaO.

	Residue
(1) Excess air present.....	158. 0d.
(2) No excess air, air excluded.....	308. 0d.
(3) Excess air, acetate to precipitate all sol. sulphides, but no excess.....	88. 0d.

Solutions off contained no protective alkalinity, and except No. 2 were free from K₂S.

It would appear that under these conditions, in a solution containing little or no protective alkali, the use of acetate in just sufficient quantity to precipitate soluble sulphides, is beneficial but may be injurious in the presence of much CaO, especially if the acetate be in excess.

Cement and Concrete

Tricalcic Silicate in Portland Cement.—According to a paper published by GEORGE A. RANKIN in the *Journal* of the Franklin Institute, the major constituents of Portland cement are tricalcic silicate, dicalcic silicate and tricalcic aluminate. Of these the compound tricalcic silicate is the one that hardens and develops the greatest strength within a reasonable time. While most important, this compound also is the one most difficulty formed, and comprises but 30 to 35 per cent of an average normal Portland cement. It may be said, therefore, that the essential process for the manufacture of Portland cement is the formation of this compound and that any improvement in the process which will increase the percentage of this constituent will add to the cementing value of the product. In order to determine the most economical process for producing this compound in higher percentages, it will be necessary to study the rate of its formation in a series of mixtures of various substances. It will be necessary also to determine the equilibrium relations of the compound at high temperatures in such mixtures. A scientific investigation of this kind will lead sooner to the discovery of the best composition than the empirical cut-and-try methods.

Specification for Concrete Aggregates.—Instead of specifying that concrete aggregates, especially sand, be of a certain fixed minimum standard of quality, which may not be attained in certain localities, it is proposed by C. M. CHAPMAN in *Engineering Record*, July 8, that the specifications shall read about as follows: "The materials used shall be of such quality and shall be used in such proportions, as to produce a concrete which shall show a compressive strength of 2500 (or 2000 or 1500) lb. per square inch at the age of 28 days, when tested according to standard methods." The author contends that specifications should be drawn to insure the production of suitable concrete if the aggregates are properly used and should permit of the use of local materials when they are capable of producing concrete of the required quality. It is better to specify the result required than to handicap the builder with specifications as to material which he cannot fulfill.

It is assumed, for instance, that for mass foundations and footings, retaining walls, abutments and similar service, a concrete of compressive strength of 1500 lb. per square inch at age 28 days is suitable. For reinforced walls and matts where stresses are moderate a compressive strength of 2000 lb. may be required,

while for reinforced floor slabs, beams, girders, columns, etc., a minimum compressive strength of 2500 lb. may be necessary. By specifying the results required and permitting the use of such materials as will produce these results when tested under specified standard conditions, it is possible not only to safeguard the products but to permit the use of locally available materials. In operating under such specifications it is important to test specimens of concrete produced on the job and check the quality of materials used so as to insure reasonable uniformity.

Distillation

Operation and Costs of an Eight-Effect Distilling Plant.—The number of bodies or effects in commercial distilling plants varies from one to twenty-four, this number having been proposed, although installations having more than eight are rare. In the *Journal* of the Engineers Club of Baltimore, June, 1916, FRANK T. LEILICH gives a description of an eight-effect salt-water distilling plant of the Lillie type. It is designed particularly for use in ice-making plants, bottling establishments and marine service.

The present tests were made on a plant installed in an isolated fortification where fuel is expensive and storage facilities limited. Diesel engine prime movers are employed and the boilers furnishing the steam for the distilling plant are fired with fuel oil. The plant was designed to meet specifications calling for 5000 gal. per day of distilled water. The average production was to be not less than 6 lb. for every 1177 B.t.u. of total heat above 32 deg. Fahr. contained in the steam supplied and a thirty-day demonstration was to be made.

The pressure ranges decided upon were 10 lb. gage to 24 in. vacuum. The shell and heads were made of cast iron, both heads being hinged, and the steam tubes were of copper. The plant was arranged to be operated with either half as a quadruple effect and both halves reversible.

During the preliminary tests the steam quality was determined by means of a throttling calorimeter. Later this instrument was rendered unserviceable by an accident, and as the contractor agreed to accept the test results on the assumption that the steam supplied contained no moisture, the damaged calorimeter was not replaced. The exhaust from the condenser pump and a condenser cooling water pump furnished nearly all of the steam required for octuple running. These pumps and the make-up passing through the reducing valve were supplied with steam at 90 to 100 lb. gage by two hoisting engine boilers.

During the first few weeks of running, the operation of the plant was not satisfactory, as the condenser pump proved to be too small and the performance of the apparatus was spasmodic. However, the purity of the distillate produced was as good as required by the specifications. Several sizes of pumps were tried before one suited to the service was secured. While experimenting with the pumps various modifications of the gas removal connections were tested out, but with the proper size of condenser pump the original connections were found to be most satisfactory. In addition to the pump and gas accumulation troubles, the removal of the condensation from the steam end No. 8, working with No. 1 hottest, was neither regular nor positive. This caused irregular discharge and reduced the rate of working, as the tubes in No. 8 would become flooded. In the opinion of the author both of the above difficulties can be traced primarily to the small pressure drop in the effects. In his opinion, a plant operating between the pressure ranges of 10 lb. gage and 24 in.

vacuum should not have more than six effects. When either half of the plant was operated quadruple, no trouble was experienced, which seems to substantiate the above view. After considerable experimenting, what might be termed an equalizer pipe running under the effects was installed connecting the condensation discharge at No. 8 with the condensation connection into the condenser. After the installation of this line, the pump removed the condensation from No. 8 as fast as it accumulated and the plant ran at a uniform rate.

The thirty-day run was started on Nov. 9, 1914, the plant being operated by three shifts of two men each. The operators were required to make hourly records of the readings of the various gages and thermometers connected with the apparatus.

When the apparatus was shut down at the end of the thirty-day run the heads were opened and the scale formations carefully examined. The tubes were coated with a substance resembling common salt, the coating being about as thick as an ordinary visiting card. Most of the coating could be scraped off with a small stick. The deposit was not analyzed, but a sample that was put into dilute hydrochloric acid was almost completely dissolved. After the completion of the thirty-day run, and without cleaning the tubes, several economy tests were made. The results of a few of these are summarized in Table I.

TABLE I

Test No.	Date	TIME		TIME		READINGS OF GAGES ON EFFECTS								Vae. Cond.	Lb. Dist. per Lb. of Steam*	GALLONS		Lb. Dist. per Lb. of Steam	Daily Rate, Gallons	Remarks
		Start, P.M.	Finish, P.M.	Reverse, P.M.	Min. Rnd.	1	2	3	4	5	6	7	8			Steam	Total Out-put			
1	1 14 15	1 15	4 15	2 38	10	21.8°	17.4°	12.4°	9.2°	5.5°	0.6°	2.1°	5.2°	24.1°	6.2	127	941	7.4	7500	Salt water "pulled over" during reversal. 1 bbl. of dist. thrown away. Room 64° F.
						5.3°	1.1°	2.9°	8.1°	11.4°	15.2°	18.7°	22.9°	24.8°	8.3					
5	1 22 15	4 35	9 10	6.38	10	5.3°	1.3°	4.1°	8.3°	12.7°	16.8°	20.7°	24.7°	25.6°	6.2	222	1332	6.0	7000	Brine pulled down four times Room, 66° F. Feed, 55° F.
						21.2°	15.3°	11.7°	7.6°	3.6°	0.6°	2.1°	4.9°	24.6°	5.7					
6	1 22 15	9 35	10 08							19.7°	11.5°	4.4°	1.8°	24.1°	5.2	36	186	5.2*	7600†	

*Effect of reversal not included.

†Calculated on a basis of 6 reversals per day, 24 hours of full capacity running.

After making several economy runs, it was found that the output per pound of steam depended considerably upon the care in operation, and individual results were difficult to reproduce.

During all tests the distillate was sampled at regular intervals. Grab samples of about 25 c.c. were taken and all samples taken during a test were poured into a clean bottle which was kept securely corked. The contents of the bottle were assumed to represent the average quality of the distillate produced during the run. The samples were tested for chlorine only. The results of the analysis of a few of the samples are given in Table II below.

Test No.	Date	TABLE II		Aver. of 4 determinations
		Operating (1915)	Aver. gr. of Cl per gal.	
1	Jan. 11	Octuple	.306	" " " "
2	Jan. 15	Octuple	.731	" " " "
3	Jan. 16	Quadruple	2.510	" " " "
4	Jan. 22	Octuple	.76	" " " "

These analyses are believed to be representative of what the apparatus will do when attended by a skillful operator. The men employed as operators during the test had no previous experience with the apparatus and worked under the supervision of the contractor's representative. After operating under these conditions for about four weeks two of the men could be depended upon to handle the plant satisfactorily. Reversing re-

quires considerable care in order to prevent "pulling over" salt water. Carrying the brine levels too high also results in a salty product. These levels are not maintained automatically, but with uniform supply pressures an experienced operator can readily find by trial the proper setting of the four-way feed cocks for continuous feeding of the apparatus.

The Lillie apparatus is especially adapted to installations where a supply of exhaust steam is available and where fuel costs require that the distillation be carried out with a minimum expenditure of heat. As regards scale formations, the Lillie plant will show to best advantage when the distillation is from sea water or other source approaching this in character. While a six or eight effect reversible plant is somewhat more complicated than the more common types of evaporators, experience has demonstrated that employees of average intelligence can, in a few weeks, become proficient in the operation of the apparatus. As usually built, the effects are arranged horizontally and hence require considerable floor space for the installation.

The cost of a plant will, of course, be dependent upon the capacity and other circumstances connected with the proposed installation. The plant described in this paper is for installation on a military post and hence the operating costs have but little commercial significance. Assuming, however, the equipment would be used com-

mercially the costs would probably be about as set forth in Table III below.

TABLE III—FIXED CHARGES AND OPERATING COSTS

A—Fixed charges (based on an investment of \$16,500 for eight-effect distilling plant complete with boilers and auxiliaries).	
Interest, 6%	\$390.00
Insurance and taxes, 1%	165.00
Depreciation, 5%	825.00
Total.....	\$1,380.00
B—Operating costs (based on operation for 300 days per year).	
Labor, one operator at \$60 monthly.....	\$720.00
Repairs and maintenance, estimated at 3% of first cost.....	495.00
Fuel—Coal at \$3.50 per ton (assumptions:—8 lbs. of steam per lb. of coal, 6 lbs. of distillate per lb. of steam, 9 hours daily operation at rate of 7,000 gals. in 24 hours, 12% allowance for steam used in warming up, leakage, etc.).....	270.00
Total.....	\$1,485.00
C—Operating costs based on operation for 300 days, 24 hours per day.	
Labor—Three operators at \$60 each monthly.....	\$2,160.00
Repairs and maintenance, estimated at 3% of first cost.....	495.00
Fuel—Coal at \$3.50 per ton (assumptions:—8 lbs. of steam per lb. of coal, 6 lbs. of distillate per lb. of steam, 7,000 gals. daily output, 8% allowance for steam used in warming up, leakage, etc.).....	690.00
Total.....	\$3,345.00
Summary:	
Total costs, (A) plus (B).....	\$2,865.00
Yearly output (300 days of 9 hours), gallons.....	787,000
Cost per gallon.....	.0044
Total costs, (A) plus (C).....	\$5,325.00
Yearly output (300 days of 24 hours), gallons.....	2,100,000
Cost per gallon.....	.0025

The above cost estimates are of necessity only rough approximations. The capital investment, it should be noted, includes the cost of boilers, etc., and is perhaps higher than it would be for an ordinary commercial plant. Operating costs do not include labor of a fireman, it being assumed that the increased load of the distilling plant could be handled without an increase in the fire-room force. This is a fair assumption, as the distilling plant attendants would have sufficient spare time to render service in other ways that would at least balance any fire-room labor charges.

Recent Chemical and Metallurgical Patents

Cyanides and Cyanamid

Production of Cyanogen Compounds.—An electric furnace process of producing cyanogen compounds and ammonia is patented by AXEL R. LINDBLAD, of Ludvika,

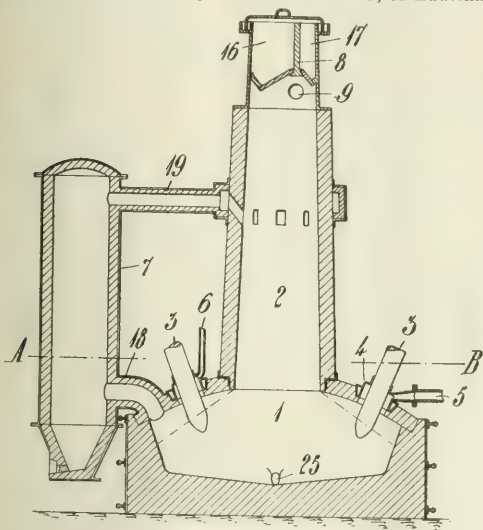


FIG. 1—CYANIDE AND AMMONIA FURNACE

Sweden. A cross-section of the furnace is shown in Fig. 1. In the manufacture of cyanides; potassium or sodium carbonate, or their hydroxides may be used. One of these is charged into the furnace through hopper section 8. Charcoal is fed in at 16, and nitrogen or a nitrogen containing gas is introduced around the electrode 3 at 5. As the charge enters the reaction zone 1, the carbonate is converted into cyanide. It is necessary to charge the potassium carbonate at the side of the furnace on which the nitrogen gas is introduced. The electrodes 3, which supply the heat necessary to carry on the reaction are water-cooled, and the introducing of the nitrogen gas around the electrode also aids in cooling. The temperature of the furnace is raised sufficiently high to gasify the cyanide formed, and any potassium carbonate which is gasified has to pass through the glowing carbon before reaching the gas outlet 18, since the carbonate is charged in the opposite side of the furnace. The gases are led to a condenser 7; where the cyanide is condensed. The gases not condensed are led back to the furnace through line 19. Any slag formed from the ash of the charcoal or other ingredients is tapped at 25.

Barium compounds may also be made, if necessary modifications are made in view of the higher melting points of the raw barium materials.

In the synthesis of ammonia by this method which has been tried before with little success, the cyanide is an intermediate product. The cyanide, formed as described above, except with the use of KOH instead of K_2CO_3 , is led in the gaseous state through chamber 18, without condensing, and led back to the furnace shaft at a higher level through conduit 19, where it meets steam introduced through a jet. The cyanide is decomposed, and the KOH regenerated with the formation of ammonia. The KOH passes through the process again while the ammonia is led off through the tap.

Auxiliary electrodes may be used at a point near the introduction of the cyanide gas and the steam to facilitate the reaction. (1,186,921, June 13, 1916.)

Production of Calcium Cyanamid.—In the production of calcium cyanamid from calcium carbide and nitrogen it has been found desirable to keep the temperature as low as possible due to the reversibility of the cyanide reaction. The reaction temperature has been reduced by the aid of catalytic substances such as calcium chloride or calcium fluoride. Another reason for the maintaining of as low a reaction temperature as possible was that undesirable sintering and dissociation took place at a temperature a few hundred degrees above the normal reaction temperature, and this temperature might easily be reached on account of the reaction being exothermic. According to a patent of JOHAN HJALMAR LIDHOLM, of London, England, a temperature considerably in excess of the sintering temperature may be used without a corresponding increase in dissociation if the carbide is passed rapidly through an atmosphere of nitrogen and cooled quickly.

A temperature of 2000 deg. C., is used in an electric furnace constructed as shown in Fig. 2. The furnace consists of a tube made of carbon having at its upper end a feeding hopper 4, with screen 5 to sift the par-

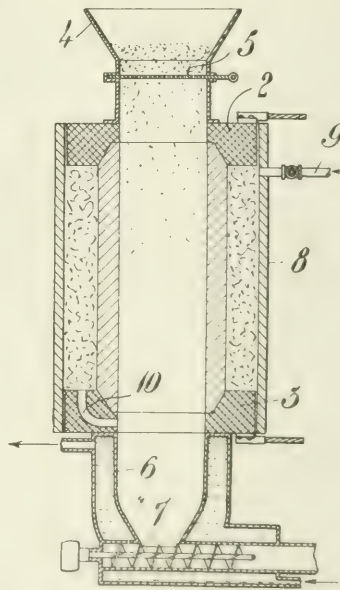


FIG. 2—CALCIUM CYANAMID FURNACE

ticles down into the furnace. The furnace is heated by resistance from contact blocks 2 and 3. At the bottom of the furnace is a water-cooled metal section 6 through which the newly formed cyanamid passes to a screw

conveyor 7, by which it is conveyed from the furnace. The nitrogen is introduced through pipe 9 into a space between the outside shell 8, and the furnace tube. This space is filled with coke and serves to preheat the nitrogen and abstract any oxygen contained therein. It is claimed that yields approaching very closely to theoretical may be obtained by this method. (1,184,109, May 23, 1916.)

Flotation Machine

An apparatus for applying the oil-flotation process, known in the industry as the K & K machine, is patented by FREDERICK B. KOLLBERG and MAX KRAUT, of Bisbee, Ariz. It is shown in vertical transverse section in Fig. 3. It consists of a revolvable cylinder or drum

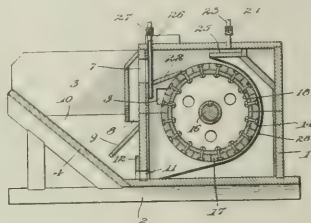


FIG. 3—FLOTATION MACHINE

14, covered with cleats forming longitudinal riffles, moving anti-clock-wise in a close housing in a spraying chamber 1. Ore-pulp to be treated is admitted through opening 5. The spraying chamber has connection with the frothing chamber 3 by way of openings 7 and 8. Air supply pipes 23 communicate with the upper end of the spraying chamber, and oil supply pipes 26 communicate with the interior of the same. In operation pulp exists in the spraying chamber to such a depth that the drum is slightly immersed. In rotation of the drum a certain portion of pulp adheres and is carried around and thrown by centrifugal force through the openings 7. Ample opportunity is afforded for complete aeration and oiling of the pulp by the rapid revolution of the drum. (1,174,737, March 7, 1916.)

Welding

Welding Scrap Nickel Anodes.—In nickel plating work, after the anodes have been consumed to the extent of 75 to 85 per cent they become ineffective and new anodes must be used. The old anodes are scrapped and returned to the manufacturers to be remelted and recast. In a novel process patented by JAMES J. WALSH of Indianapolis, Ind., and assigned to the Prest-O-Lite Company, Inc., of Indianapolis, Ind., it is proposed to weld these scrap anodes together and use them again as new anodes. The welding is done by the oxy-acetylene flame, by heating two scrap anodes to the fusing point and then depositing hotter molten nickel on the joint, thus building up a homogeneous joint. A number of anodes are thus joined until the size is sufficient for use in the plating bath. (1,185,959, June 6, 1916.)

Alloy for Arc Welding.—An alloy to be used in the arc welding of iron and steel is patented by DAVID H. WILSON, of Paterson, N. J., and SANSOM M. RODGERS of Pittsburgh, Pa. The alloy consists of iron, manganese, copper, and carbon; successful proportions being 0.60 to 1.00 per cent manganese; 0.25 to 0.40 per cent copper, 0.18 per cent or less of carbon and the balance, iron. With these proportions a desirable voltage is 35 with electrodes 0.15 in. in diameter. The excess of manganese and copper, over the amount burned out in the arc has the effect of preserving the strength of the weld to a greater extent than formerly. The manganese protects the carbon and the iron, and the copper

reduces the melting point of the alloy and thus the welding temperature. It has been found desirable to weld at the lowest temperature possible, as the welding metal is less affected by the arc, flows more evenly and makes a better weld. (1,187,411-12, June 13, 1916.)

Sodium and Alkali Metals

Electrolysis of Fused Alkali Chlorides.—An apparatus for the production of alkali metals from alkali chlorides such as sodium from sodium chloride is patented by JOHANNES PFLEGER and FRIEDRICH OTT, of Frankfort-on-Main, Germany, and assigned to the Roessler and Hasslacher Chemical Company of New York. The apparatus is similar to the Castner apparatus in which fused caustic alkali is electrolyzed with the production of sodium. The application of the Castner apparatus to the electrolysis of sodium chloride has been previously tried and was the subject of German Patent No. 236,804. In this patent it was proposed to use two partitions separated from each other, made from different materials for the separation of the products by electrolysis. This scheme was, however, too complicated.

In the present patent it is claimed that all that is necessary is to make the part of the apparatus which is subject to chlorine gas, proof against this gas, and then the sodium chloride may be successfully electrolyzed. A diagram of the apparatus as so arranged is shown in Fig. 4. A receptacle A, of iron serves as a

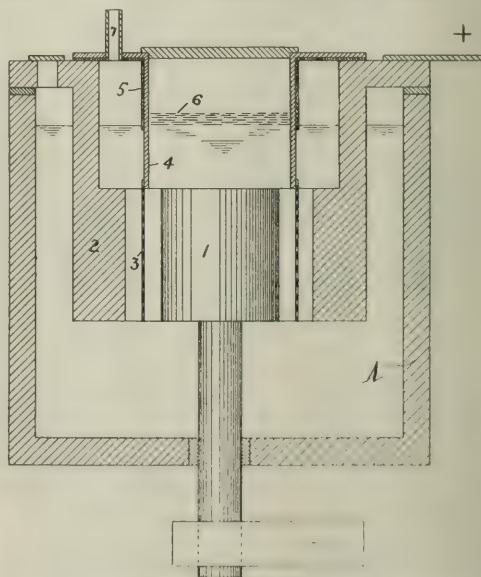


FIG. 4—CROSS-SECTION OF ELECTROLYTIC APPARATUS

container for the electrolyte and electrodes. The cathode 1, is of iron and the anode 2, of carbon. The electrodes are separated by a wire screen 3, which is connected with an iron receptacle 4, covered at the top. The outside of this iron receptacle is covered by a preparation 5, which is not attacked by chlorine gas. This preparation consists of asbestos thread impregnated with a thin paste-like mixture of water, glass and asbestos flour. This is wound around the vessel, and is ready for use when dry. The use of solidified salt as the chlorine resisting material is the subject of a second patent. In the operation of the cell the sodium formed collects at the cathode in 4. The chlorine escapes through pipe 7. (1,186,936, June 13, 1916.)

A Pneumatic Powdered Coal System

The use of powdered coal as a fuel has received very considerable attention in the metallurgical industries during the last few years; after, in the Portland cement industry, it had found a wide application for a long time.

tance from the furnaces, and it is necessary that the distributing system be efficient.

The essential features of the Holbeck system are shown in Fig. 1. Bituminous crushed, nut or slack coal is stored in a bin, preferably made of steel or concrete. The coal passes from the bin and an automatic

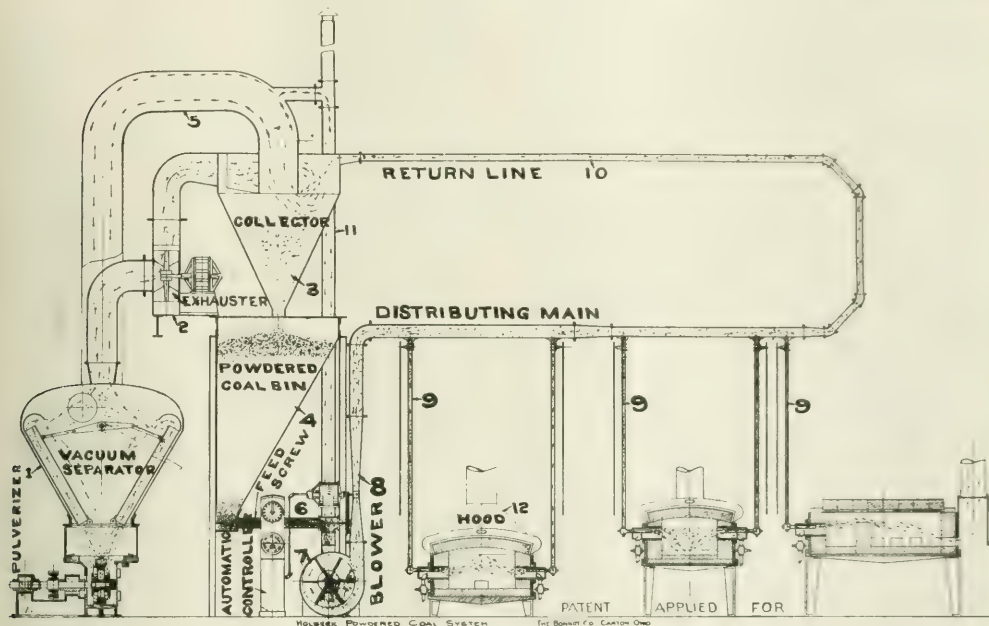


FIG. 1—DIAGRAM OF POWDERED COAL SYSTEM

For reverberatory furnaces powdered fuel is used on a large scale at Copper Cliff and Anaconda.

For metal heating furnaces an interesting system has been developed by A. A. HOLBECK of the Bonnot Company, Canton, Ohio. This system, which is supplied by the Bonnot Company, makes it possible to distribute the fuel to widely scattered furnaces. The coal-pulverizing plant is necessarily located some dis-

tance from the furnaces, and it is necessary that the distributing system be efficient. As the coal becomes pulverized it is thrown up into the vacuum separator 1 by the action of the pulverizer. This separator separates the fine particles of coal dust from the coarse, the finest being drawn into the exhauster 2, the coarse falling down into the pulverizer.

From the exhauster 2 the powdered coal is blown into the collector 3. The expansion of the air as it enters the collector permits the coal dust that is carried in suspension to fall to the bottom of the collector and into the coal storage tank 4. The air that enters the collector returns through pipe 5 to the pulverizer to be used over again.

The coal dust is taken from the storage tank 4 by the feed screw 6 and delivered into the suction side of high-pressure blower 7. It is then blown into the distributing main 8, and carried to the furnace through the distributing pipes 9.

The coal which is not used at the furnaces is returned through the return line 10 to the collector 3, where it is extracted from the air and falls into the coal storage tank 4 to be used over again.

The air after the coal is extracted is returned to the suction side of the blower through pipe 11. The products of combustion from the furnaces are collected by the hoods 12 placed in front of each furnace, and are disposed of either by means of an exhaustor or a stack.

In Fig. 2 is shown an ingot-heating forge furnace equipped with this system, showing the powdered coal connections and burners.

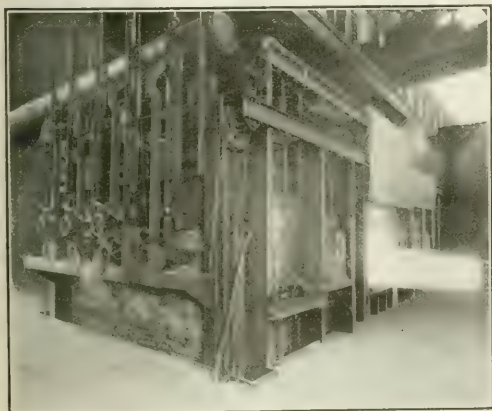


FIG. 2—INGOT HEATING FORGE FURNACE EQUIPPED FOR POWDERED COAL BURNING

A Comparison of Oxy-Hydrogen and Oxy-Acetylene Cutting

BY WALTER P. SCHUCK

The recent installation throughout the country of plants producing oxygen by the electrolytic process has resulted in many cases in the production of a comparatively large amount of pure hydrogen as a by-product. The uses to which this hydrogen can be put are consequently of commercial importance. It has been well known that hydrogen in connection with oxygen is essential for cutting thick plates of steel. For cutting steel plates up to about 5 in. thick acetylene can be used for the pre-heating flame, but heavier sections require the use of hydrogen.

Even with this known advantage of hydrogen there are fewer makes of cutting torches adapted to the use of hydrogen with oxygen than those adapted to the use of acetylene with oxygen. This is probably due to the fact that hydrogen is less extensively used with oxygen for welding than acetylene, and most cutting torches are developed by makers of oxy-acetylene welding torches. Recently a combination cutting torch, known as the "Modern," that can be used with either oxy-hydrogen or oxy-acetylene by changing the tips, was developed, and while it does good work with acetylene the trials showed the use of hydrogen to be so much more economical that the writer was requested to observe a series of tests and measure the gas used.

The procedure in these tests was to first determine the minimum pressure of oxygen that would satisfactorily cut the thickness of steel on trial, and then measure the speed of cutting and the amount of each gas used. The pre-heating gas, whether hydrogen or acetylene, was delivered to the torch at the pressure necessary to maintain the proper flame with the valve at the torch wide open. The oxygen used in connection with hydrogen or acetylene for the pre-heating flame had to be regulated by means of the valve on the oxygen line at the torch, because the oxygen pressure in the hose to the torch had to be heavy enough to do the cutting required. After the proper oxygen pressure had been determined a convenient length of cut was made and timed by taking the time from the instant the cutting jet of oxygen was started until the cut in the steel was finished.

The oxygen used for each thickness of steel was measured by a counterpoised gas meter, by shutting off the hydrogen or acetylene at the torch and leaving the

In terms of the amount of gas used per lineal foot of cut and the cost of cutting, these data present some very interesting facts as shown by Table II.

TABLE II
Gases Used per Lineal Foot of Cut, and Cost of Gases per Lineal Foot.

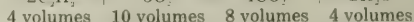
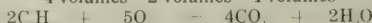
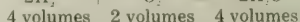
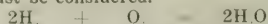
Thickness of Steel, Inch	Oxy-hydro.	Oxy-acety.	Oxy-acety. (Acet. 1c)	Oxy-Acety. Oxygen Only
$\frac{1}{4}$	\$0.016	\$0.043	\$0.034	\$0.027
$\frac{1}{2}$	0.037	0.096	0.078	0.064
1	0.071	0.165	0.142	0.124
$1\frac{1}{2}$	0.093	0.215	0.187	0.164
2	0.114	0.291	0.259	0.230

The cost of oxygen was taken at 2c. per cubic foot, hydrogen at $1\frac{1}{2}$ c. per cubic foot, and acetylene at $2\frac{1}{4}$ c. per cubic foot, and also at 1c. per cubic foot. The amount of oxygen required when using acetylene as the source of heat for pre-heating is so much greater than when using hydrogen that it would be cheaper to use the oxy-hydrogen process at the prices named, than to use oxy-acetylene even if the acetylene were obtainable free of cost. This seems such a strong showing in favor of the oxy-hydrogen cutting that an explanation should be had.

The writer believes that in view of the well-known deleterious effect of even small amounts of the non-combustible gases when cutting steel with oxygen (see Tucker, *Journal of the Society of Chemical Industry*, Vol. XXX, page 779, July 15, 1911) the low efficiency of oxy-acetylene cutting can well be explained by the presence of the carbon dioxide resulting from the combustion of acetylene. A part of the gases resulting from the combustion of either hydrogen or acetylene are drawn into the cut by the suction of the oxygen jet. In the case of hydrogen this means that water vapor and nothing else will dilute the oxygen used for cutting, while with acetylene both carbon dioxide and water vapor are introduced. This is clearly shown by the chemical equation of the union of these gases with oxygen.



These equations, however, show only the molecular relation of the combustion of these gases, and for a true understanding of the amount of carbon dioxide involved the volumes entering into the reaction as shown in the following must be considered.



In short, this means that the complete combustion of one volume of hydrogen produces one volume of water vapor, while acetylene produces its own volume of water vapor plus twice its volume of carbon dioxide. This additional carbon dioxide dilutes the cutting jet of oxygen to such an extent that a great deal more must be used than is necessary when burning hydrogen.

The gases used in these tests were: electrolytic oxygen 99.5 per cent pure, electrolytic hydrogen 99.8 per cent pure, and acetylene from a commercial tank of com-

TABLE I

Thick-ness of Metal, Inch	CUTTING SPEED Ft. per Hr.		PRESSURES AT WHICH GASES ARE USED				GAS CONSUMPTION, CU. FT. PER HR.			
	Oxy-hydro.	Oxy-acety.	Oxy.	Hydro.	Oxy.	Acety.	Oxy.	Hydro.	Oxy.	Acety.
$\frac{1}{4}$	90	100	5	2	12	10	47	35	110	71
$\frac{1}{2}$	45	50	5	2	15	10	56	45	160	71
1	16	39	12	5	35	10	90	71	242	71
$1\frac{1}{2}$	35	32	15	5	40	10	101	71	263	71
2	30	28	20	5	55	10	123	71	327	71

oxygen flow from the torch just as it had while making the cut. To guard against any back pressure in the gas meter, due to friction, a water-filled U-gage was connected to the intake pipe of the gas meter and the water in it kept level during the passage of the gas and when it was measured. The hydrogen and acetylene were measured in the same way after the flame had been relighted, adjusted and then the oxygen shut off and the flame extinguished by putting the torch under water. Table I gives the data derived from these tests.



CUTTING TESTS

pressed gas held in solution by acetone. These tests were all made using the torch moved by hand along a guide and represent fair average practice with the equipment mentioned. With gases of poorer quality, such as oxygen made from air, the speeds given can not be maintained and greater pressures must be used.

A trial of cutting 1-in. steel plate was made using atmospheric oxygen with hydrogen and also with acetylene, and the results are clearly shown in the accompanying photograph. Each of cuts numbered 1, 2, 3 and 4 represents the longest cut possible to make in this material in two minutes, using the same size cutting tip and the least pressure of oxygen that will make a thorough cut. Cut No. 1 was made with electrolytic oxygen 99.5 per cent pure and electrolytic hydrogen. Cut No. 2 was made with electrolytic oxygen 99.5 per cent pure and acetylene. Cut No. 3 was made with atmospheric oxygen 97.4 per cent pure and electrolytic hydrogen. Cut No. 4 was made with atmospheric oxygen 97.4 per cent pure and acetylene. All previous cuts were covered and not visible to the operator when making a cut.

Portland, Oregon.

Personal

Mr. David F. Baker, formerly connected with the blast furnace department of the Broken Hill Proprietary Company at New Castle, New South Wales, is in this country and will take up permanent work here.

Dr. Wallace P. Cohoe has moved his office and laboratory from the Chemists' Building, 50 East Forty-first Street, New York, and has taken an office in the Trinity Building, 111 Broadway. His laboratory has been moved to Bertrand Avenue, Perth Amboy, N. J., where he now has facilities for carrying out investigations under manufacturing conditions.

Mr. F. G. Cottrell was in Denver recently in conference with officials of the Bureau of Mines. He expected to visit Anaconda and other western plants before returning to Washington.

Mr. Noel Cunningham, formerly of the Dorr Company, has opened an office as consulting metallurgical engineer at 200 Fifth Avenue, New York.

Prof. H. O. Hofman, of the Massachusetts Institute of Technology, has been making a trip through the West visiting lead smelters at Chicago, Omaha, East Helena, Northport, Trail, Selby and Tooele.

Mr. W. R. Hulbert, sales manager of the Goldschmidt Thermit Company of New York, delivered an illustrated lecture, supplemented with practical demonstrations, on the theory and practicability of making thermit welds, to the members of the Clinchfield Railway Club, at Erwin, Tenn., on Tuesday evening, July 25.

Mr. Robert M. Keeney has been in Denver on professional business.

Mr. Karl L. Kithil will be in charge of the new station of the Bureau of Mines recently established at Tucson, Ariz. For several years past he has been on the bureau's staff at Denver.

Mr. Van H. Manning, director of the Bureau of Mines, is on a trip of inspection to the western stations of the bureau. He expects to select the location for a northwestern station before his return.

Mr. Ernest B. Nelson, formerly connected with the Chile Exploration Company, Chuquicamata, Chile, has accepted a position with the Andes Exploration Company, Chanaral, Chile.

Mr. Charles Pascoe, formerly metallurgist for the Canadian Steel Foundries, Ltd., and recently connected

with the Thos. Davidson Manufacturing Company, Ltd., of Montreal, as consulting metallurgist, has joined the Snyder Electric Furnace Company of Chicago, Ill., as metallurgist in that company's electric furnace research plant at Clearing, Ill. Mr. Pascoe's work in connection with the Thos. Davidson Manufacturing Company had to do with the production of shell billets from a Snyder electric acid steel furnace. Mr. Douglas Walker, former salesman for the Snyder Electric Furnace Company, and in charge of the Chicago district, has been appointed sales manager.

Mr. W. G. Savage, associated for many years with the Chicago office of the United States Cast Iron Pipe & Foundry Company, has been appointed assistant sales manager in charge of Western territory.

Mr. H. W. Seldon, manager of the metallurgical department of the Scientific Materials Co., Pittsburgh, Pa., has resigned to become assistant to the superintendent of the Franklin Open-Hearth Department of the Cambria Steel Co., at Johnstown, Pa.

Mr. Louis E. Strathman, manager and chief engineer of the pumping department of the Allis-Chalmers Manufacturing Co. of Milwaukee, Wis., was recently elected president of the Engineers Society of Milwaukee.

Mr. Melbert W. Taber, formerly manager of maintenance and construction of the Packard Motor Car Company, has been appointed manager of the Detroit office of the Asbestos Protected Metal Company of Pittsburgh, Pa. The Detroit office is located in the Penobscot Building.

Industrial Notes

The J. P. Devine Company, Buffalo, N. Y., has recently issued Bulletin 101 describing vacuum chamber dryer units that are adapted for the drying of materials that can be handled on trays or pans; Bulletin 102, describing the Devine vacuum drum dryers, adapted for all liquids and solutions containing solids, drying same to a powder; and Bulletin 103, describing Devine vacuum rotary dryers that are used in connection with drying materials that can be mixed or tumbled in the drying.

The School of Applied Industries of the Carnegie Institute of Technology, Pittsburgh, Pa., has completed its first decade in industrial education and the results have been highly gratifying. Almost 10,000 students have been enrolled at some time or other during these years, 476 of whom have been awarded diploma or certificates of graduation. Four industrial courses covering three years each are offered, viz.: machine construction, building construction, general equipment and installation, and printing. A one-year intensive trade course is also offered. The school has been under the direct charge of Dean Clifford B. Connelley.

Russian Trade.—R. Martens & Co., Inc., New York, exporters, are expanding their export operations in Russia. The original purpose of limiting their operations to the mechanical lines of industry will be strictly adhered to. But to conserve the tremendous opportunity for non-mechanical lines, they have created a subsidiary company under the name of "Russia Trade Corporation of America." The new concern will have a complete business organization and its general offices will be in the Maritime Building, 8 and 10 Bridge Street, New York, and all business transactions will be entirely separate and distinct from the parent company.

Messrs. Eimer & Amend, New York City, have filed plans for the new ten-story addition which will be

built to the present store at Third Avenue and Eighteenth Street. The cost will be \$100,000.

The Improved Equipment Company, 60 Wall Street, New York, has added a new department, to be known as the Boiler Department. This department will offer its services for the design of steam boiler furnaces, hand fired; automatic stokers, forced-draft equipment for all types of furnaces and stokers; oil, tar and gas burners and complete plants for these fuels; pulverized and crushed coal furnaces and apparatus.

The Sarco Co., Inc., New York, have appointed Newton-Johnson, Sales Engineers, as sales representatives in Wisconsin and the northern peninsula of Michigan.

The John A. Crowley Co., Detroit, Mich., announce the sale of 2 Gronwall-Dixon furnaces which will be installed shortly. One of these furnaces will be used for sheet bars and the second for high-grade tool steel.

The Titanium Alloy Mfg. Co., Niagara Falls, N. Y., has recently added to its bronze department sales force Mr. Gilbert T. Mason, formerly secretary and treasurer of The Atkinson Co., Rochester, N. Y.

The Colorado Iron Works Company has issued Pamphlet 24-B describing the Akins classifier, Pamphlet 9-B describing the Impact screen, and Pamphlet 30 describing crushers and rolls.

The Nash Engineering Co., South Norwalk, Conn., has issued Bulletin No. 5, describing the Nash hydro turbine, air compressors and vacuum pumps, single-stage type.

The American Blower Company, Detroit, Mich., has issued Bulletin No. 17, series 3, describing "A, B, C" heaters for use in heating, ventilating, and air conditioning work; and Bulletin No. 17 series 4, describing "A, B, C" unit heaters for special work in various industries.

Instruction Book on Oxy-Acetylene Welding and Cutting.—A nicely arranged little book has been gotten up by the Prest-O-Lite Co., Inc., of Indianapolis, Ind., on the practice of oxy-acetylene welding and cutting. The authors are H. Sidney Smith and A. F. Brennan. The purpose of the book as stated in its preface is to present, in the simplest language, a brief description of the practical application of oxy-acetylene welding and cutting in the metal trades. It has been written especially for the man with little or no knowledge of the process.

New Refinery Construction in Baltimore.—The Baltimore Copper Smelting & Rolling Co., Baltimore, Md., began work Aug. 3, on the construction of an addition to its plant to include 700 tanks. The contract for the lead burning was awarded to H. G. Klink of Whiting, Ind.

Synthetic Ammonia.—The Badische Anilin und Soda Fabrik, Ludwigshafen, Germany, has increased production greatly at its new plant producing ammonium sulphate by the Haber process. According to the *Chemical Trade Journal and Chemical Engineer* (London), the large demand for fertilizers in Germany, since the outbreak of the war, due to imports being stopped, is responsible for recent large extensions at this plant, over 2000 men now being employed. Still larger works are now being built near Carbetha, on the Saale, which will employ 6000 persons.

New Oil Refinery.—The Sinclair Oil & Refining Corporation plans the construction of an 8-in. pipe line from the Oklahoma fields to Chicago and the erection of two refineries, one at Chicago and the other at some point on the Mississippi River. The pipe line will cost \$8,000,000, the refineries costing about \$2,000,000.

Warren Webster & Company, Camden, N. J., has issued a beautifully illustrated catalog describing the Webster vacuum system of steam heating. An outline is given of the development of the apparatus, followed by a description of its design and installation. Other special Webster features are also described, such as feed-water heaters, meters, steam separators, traps and air-conditioning apparatus. A series of photographs of buildings in which Webster apparatus is installed is included.

Locomotive Cranes.—The Brown Hoisting Machinery Co., Cleveland, Ohio, has issued an illustrated booklet describing Brownhoist locomotive cranes. These cranes have found application in railway work, contracting, steel, coal, lumber, mining and manufacturing industries. The catalog describes the different operations, showing how and where some of them are used.

Large Junk Pile in 1915.—The recovery of secondary metals in 1915, as given in the report of the Geological Survey by J. P. Dunlap, shows a great increase over the 1914 recovery both in amount recovered and in the value of recovered products. The secondary metals include copper, lead, zinc, antimony, tin and aluminum. The value of these metals recovered was \$114,304,930 in 1915 as compared with \$57,039,706 in 1914. The amount recovered was close to 400,000 short tons as compared with about 286,000 short tons in 1914. The high price of metals in 1915 stimulated efforts to save scrap and caused the refiners of scrap to work to the limit of their capacity. Dealers in and smelters and refiners of waste metals experienced the greatest period of prosperity ever known. The statistics of secondary metal recovery are valuable as an adjunct to the primary production as they show the total amount of the metals available for consumption.

SECONDARY METALS RECOVERED IN THE UNITED STATES IN 1914 AND 1915

Metal	1914		1915	
	Quantity (Short Tons)	Value	Quantity (Short Tons)	Value
Secondary copper, including that in alloys other than brass.....	58,556	\$15,435,362	99,937	\$33,498,882
Remelted brass.....	99,088	21,034,300	137,500	40,788,000
Secondary lead.....	29,337		36,400	
Recovered lead in alloys.....	31,725	4,762,836	42,500	7,416,600
Secondary spelter.....	42,969		52,900	
Recovered zinc in alloys other than brass.....	3,914	4,782,066	5,300	14,433,600
Secondary tin.....	1,535		5,250	
Recovered tin in alloys.....	7,912	8,887,158	8,400	10,554,180
Secondary antimony.....	1		2	
Recovered antimony in alloys.....	2,645	444,844	3,100	1,811,568
Secondary aluminum.....	2,791		5,700	
Recovered aluminum in alloys.....	1,731	1,673,140	2,800	5,802,100
		57,039,706		114,304,930

Book Review

The American Fertilizer Handbook for 1916. Ninth annual edition. 400 pages; price \$1.00. Philadelphia, Ware Bros. Company.

This is the ninth annual edition of this valuable handbook relating to the fertilizer industry. The directories of fertilizer manufacturers, cottonseed oil mills, allied trades, packers and renderers have been carefully revised up to date. Statistics for 1914 and 1915 of potash and nitrogen products, as furnished by the Geological Survey, are included in the book. Special articles are included on the Cyanamid Industry-World Status, by E. J. Franke; Preventable Losses in Fertilizer Plants, by S. J. Martenet; Possible Sources of Potash in America, by Frank K. Cameron, and The Sulphuric Acid Industry, by Andrew M. Fairlie.

Metallurgical and Chemical Engineering

A Consolidation of
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Two Coming Technical Society Events

The last two weeks of September will bring two technical society events of nation-wide importance. During the week of September 18 the American Institute of Mining Engineers will meet in Arizona, now easily the leading copper-producing State. This will be the first Arizona meeting in the Institute's history of forty-five years. Sessions will be held in the principal mining centers of the State, the members traveling between the various points by special trains and automobiles. An excellent technical program has been arranged, including an important discussion on concentration and flotation. The principal sessions will be held at Santa Rita and Hurley, N. M., and at Douglas, Bisbee, Globe and Phoenix, Ariz. The inspections will include the Roosevelt Dam, the mines and works of the Chino Copper Co., the Copper Queen Consolidated Mining Co., Calumet & Arizona Copper Co., Shattuck Copper Co., Inspiration Consolidated Copper Co., Miami Copper Co., Old Dominion Copper Mining & Smelting Co., together with the new works of the International Smelting Co. There can be no doubt that the Arizona meeting will be as enjoyable and successful as the unforgettable Montana, Utah and California meetings of the past three years.

The week of September 25 will be Chemical Week in New York City. The Second National Exposition of Chemical Industries will be held at the Grand Central Palace, and it is now assured that it will be even bigger and more representative than the immensely successful First Exposition of last year. In conjunction with the exposition the two largest national chemical societies of this country—the American Chemical Society and the American Electrochemical Society—will hold meetings in New York City, and unusual efforts are being made to render these events as enjoyable and profitable as possible.

The only pity is that the Arizona meeting of the Mining Engineers and the chemical exposition and conventions come so near together as to make it practically impossible for any one to attend both events. Yet mining engineers and chemists would do well to try and get a little bit better acquainted.

Steel Capacity After the War

The American iron and steel industry never shows a perfect alignment as to capacity in the different departments. All departments strive for maximum output when the market will absorb the product and every period of activity witnesses wholesale breaking of records whereby balances between departments are disturbed. Then there are fluctuations in the alignment of demand, the consumption of some finished steel

products increasing more rapidly than that of others. In 1903 the production of structural shapes was 27 per cent less than the production of wire rods; in 1913 the production was 22 per cent greater. Until 1904 the production of rails exceeded that of plates and sheets; in 1913 plates and sheets exceeded rails by 64 per cent.

The war has furnished the greatest disturbance of all, and the alignment of capacities in the different departments at the close of the war will doubtless be found quite unsuited to the conditions of a peace demand. There has been a remarkable increase in the production of ingots, as compared with the production of pig iron on the one hand and of finished steel on the other. A part of the increase in ingot production is attributable to the unusually large supplies of heavy melting steel available, due to the heavy cropping involved in the manufacture of shell steel, and this excess will automatically disappear. Apart from this increase, however, there has been an increase in the steel-making capacity relative to finishing capacity, and this will not disappear. The excess is represented at present in the exportation of large tonnages of forging billets and other unfinished steel, together with large tonnages of rounds rolled on rail mills. The rail mills are very busy, although the domestic demand for rails has been relatively light.

The most striking lack of harmony disclosed by the actual market prices prevailing is the shortage of steel-making capacity relative to pig-iron producing and steel-finishing capacity, whereby there is an unprecedentedly large gap between pig-iron prices and unfinished steel prices. Basic pig iron has been selling at an average price of \$19 to \$20, delivered at steel works, while billets, slabs and sheet bars are quoted nominal at \$45 to \$50, being almost unobtainable at any figure. Light gage sheets and wire nails are selling at considerably less than the bare cost of conversion above the current market prices for their raw materials. The market price of unfinished steel is not made by demand for sheet bars, or perhaps, even for billets, in the domestic market, but is caused by high bids for slabs from domestic plate mills, and by heavy export demand for nearly all descriptions of unfinished steel. After the war the alignment will necessarily be quite different. Pig iron and unfinished steel will not be so widely separated. Plates will not sell at \$8 a ton more than structural shapes.

Tied Hands

We are just as patriotic as the next fellow; we hold the fair name and fame of our beloved land as a sacred thing and we do not believe in carping criticism. But sometimes we get a little confused. We stand by the Constitution, but we do not always know just which way to look while we are standing there. For instance, here is a letter from the Director of the United States Geological Survey to one of the managers of the Chemical Exposition, which we print with permission: "I regret with you that there is practically no possibility of Congress passing a bill appropriating funds to allow the Government Bureaus participating in the Second Na-

tional Exposition of Chemical Industries. In view of Congress' apparent desire to prevent the various bureaus taking part in this project as well as its former order against allowing employees to be detailed to scientific meetings, etc., at the expense of the Government, I am constrained to inform you that it will not be possible for the Survey to send an exhibit to New York for the exposition and it will therefore be unnecessary to hold space for our use. I trust that several of the chemists and geologists will be able to visit the exposition on leave at their own expense, and I hope that you will meet with the same success that attended the first exhibit of this sort."

It is all right for Congress to hold a tight rein upon the Government, but does it take a special bill to send up a little exhibit? The work of the Government for the people needs to be brought to their attention so that they may know what it is doing—at least, so it would appear—and yet Congress, so lavish with post-office buildings for small towns and special pensions that have been refused by the pension authorities and the dredging of small creeks for the "extension of commerce," seems to think otherwise.

That will be quite an exhibit in the last week in September, and if present signs do not fail, it will be very largely attended. The Geological Survey works for all the people. It costs far less than pensions and it is more useful and more interesting. It knows a great deal about the mineral deposits of the country and industry would like very much to be posted. This would extend commerce far more than many of the duck ponds for which Congress has made such generous appropriations. Maybe Director Smith draws too fine a line in regard to the authority vested in him, and yet if he can't exhibit, we don't see how he can. It is confusing; very confusing. Especially as the Bureau of Mines is sending a very considerable exhibit.

The Byproduct Coke Oven

In our issue of July 15 (page 56) we commented on the marvelous rate at which the iron industry of this country is now adopting the by-product coking process. But as a remark at the end of that note concerning the by-products recovered has been misunderstood, it may not be amiss to restate the situation exactly. The facts are that there are practically no by-product coke plants in the United States, which do not recover ammonia, tar and light oil (crude benzols). In the vast majority of the plants also surplus gas is recovered and utilized either at the plant itself or by distribution to outside consumers. There are possibly two or three very small by-product coke plants at which tar and ammonia are not recovered for disposal to the outside markets, but these would certainly represent considerably less than 1 per cent of the total by-product coking capacity. There is not over 5 per cent of the by-product coke oven capacity of the country that is not now equipped with benzol recovery plants, and the by-product coking plants now under construction have either contracted for benzol recovery equipment or indicated a strong probability that such provision will be made.

This development is industrially important and interesting in more than one direction. We may consider the utilization of the by-products recovered and rejoice of the foundation of new industries in this country. This is perhaps the most natural way to look at the by-product coke oven development. But we may also consider the effect which this development has had on the iron industry. One of the most interesting technical effects is brought out very clearly in the article by Mr. J. E. Johnson, Jr., on commercial considerations concerning the blast furnace, published in this issue. A few years ago maximum degree of fuel economy was not only technically desirable, but was commercially necessary for survival, but this is no longer the case. There are conditions in which the commercial results are better with very moderate fuel economy than with the highest. The two developments which have brought about this change are the introduction of the by-product coke oven and the economic development of power generation with blast furnace gas, especially the gas engine. Mr. Johnson's very lucid demonstration of this peculiar situation should be read with decided interest.

The Commissioner of Chemistry

There is a man in Jamaica, Long Island, who has a boy named Donald, twelve years old. He left home for a visit to Mount Beacon, N. Y., and he returned a week later. "When Donald went away," said his father to a New York World reporter, "he was four feet ten inches in height and weighed seventy-two pounds. When he got back to-day his mother was so amazed at his appearance that we measured him again and found that he was five feet two and three-quarters inches tall and weighed eighty-two pounds."

He had grown four and three-quarters inches in eight days.

Donald is like some chemical industries in this country in that both have made a record growth, but there the resemblance ends. Donald has a father and mother to look after him, to discourage cigarettes and wet feet and bad companions. It is not so with many of our blooming young chemical industries. They have no father and mother to look after them. What will they do on the day when they get cold feet?

Some time or other the big war will be over and ships will be sailing on the seas. The Japanese have entered into the chemical habit, and a lot of munition works in the Rhine country will shift back into making other chemical products. They can do it because the equipment is there. The reporter who thought that all the shell makers and TNT institutions and "Pickwick Acid" layouts in the United States could shift over into making alizarine and indigo and fast cotton colors and intermediates and all the wanted things, by a twist o' the wrist, was wrong; but over in Germany the equipment and the art to make the things they used to produce will be available. Chemical manufacture is growing in Norway and Sweden by leaps and bounds, and England has developed a chemical consciousness. The Scotch have taken to chemistry, and that means trouble—outside of Scot-

land. In all of the countries mentioned there is great encouragement for manufacturers to get together and co-ordinate their work. Every country is resolved to be self-contained or burst a lung in the attempt, and every country is also firmly resolved to cultivate and prosecute an active export trade. Now, nobody outside of Congress believes that in American chemical industry there is good, co-ordinated system. And the time is coming when these efforts at export trade will be made by sister nations on every hand. Then we can talk protection until we are blue in the face and insist upon it that the man who buys foreign goods is without patriotism and we can call him a traitor and all the hard names we can think of—but nothing will help except system and order and co-ordination.

So chemical industry needs a leader who is long on knowledge and experience in the markets as well as in industry; who can say disagreeable things and yet be cheerful about it, and who is not committed to any particular organization. He should be a successful man who has made his pile and who has a liking for bringing about results. The place for him would be in some department of the government at Washington, where information would come to him at first hand and where he could do some co-ordinating without breaking the law.

This sort of thing can only be done from the Heights of Government. We have the grave difficulty that only Government may do those things that business men may do in most other countries. Under the Sherman law, a tricky lawyer can construe nearly every manufacturer, no matter how conscientious and innocent of all evil he may be, into a criminal by a possible "theory of the case"; and American manufacturers have lost initiative under it. Some manufacturers' associations have dwindled down into weak imitations of a comedy hen-party in which the talk, restricted to the difficulties with household servants, is changed over into talk restricted to the guile and the wiles of labor unions. The iron and steel industry is in good shape because manufacturers learned the value of co-operation before the Sherman law broke out and they have the habit of keeping themselves posted. The chemical industry is not in this condition and manufacturers are not posted. And they dare not post themselves save under a standing threat from the Attorney General.

The Agricultural Department keeps farmers informed about the wheat crop, the cotton crop, foreign production and the markets. Why not do the same for chemical industry. Everybody wants chemical industry to thrive, and it cannot thrive unless it knows what is being made and landed, where it is coming from, how much of various materials are being produced and something about the markets. It needs the same kind of paternal care that it gets in other countries just as much as it needs protection.

We have no idea where the Commissioner of Chemistry would fit in, but there is room for him and need of him—unless he is to be a politician, or, in fact, any one other than a man worth far more than his salary.

Readers' Views and Comments

Electrometallurgy of Iron and Steel and Pacific Coast Waterpowers

To the Editor of Metallurgical & Chemical Engineering

SIR:—In your issue of July 1, in a very interesting article by J. W. Beckman dealing with electrochemical possibilities on the Pacific Coast as compared with those in Sweden and Norway, reference is made to the new electrothermal iron reduction which has been developed on a very large scale in Sweden, and as I am intimately acquainted with this situation I thought some information on the point might be interesting.

Mr. Beckman states that about 50,000 tons of iron are produced annually in the Swedish electric reduction furnaces. I may say that the output is now considerably over 100,000 tons, but it may be that Mr. Beckman's figures relate to a period about two years ago. Since then very large furnaces have been built which have a capacity of 10,000 hp. each, producing roughly 25,000 to 30,000 tons of pig iron annually. Compared with the ordinary blast furnaces, this capacity is, of course, only small, but it must be remembered that a very high-grade quality of pig iron is obtained, fetching good prices.

Most of the electric-furnace installations are in the middle of Sweden, whereas the ore for several of them is transported from the far north, being hauled about 200 miles by railway, then 800 miles in ships, and then again a short rail journey at the other end. Charcoal is delivered to the iron works by the railways, and the collection area is enormously wide, so that it is not unusual for charcoal to be transported 300 miles. These facts are important when contemplating similar developments on the Pacific Coast. Mr. Beckman mentioned quite rightly that so far most of the charcoal is made direct in the forest in the old-fashioned way, but the tendency is now to concentrate in large plants, especially in connection with sawmills, where all the refuse is used for making charcoal. In such cases the plant is equipped with apparatus for distillation and preservation of by-products which, if properly done, yield so high a profit that the charcoal can be sold at a very low figure.

I venture to say that there is no place in the world where conditions are so exceptionally suitable for electric iron ore reduction as the Pacific Coast of the United States and Canada. If enterprising people went about this affair in a proper way, it should be extremely remunerative and help to develop industry generally. It would, of course, be advisable to make use of the reliable experience which has now been accumulated by Swedish engineers, and this is represented by a British firm, Electro-Metals, Ltd., of London, which controls all the American patents.

In Sweden, experiments have been carried out with many different types of furnaces, but only one type has proved to be a commercial success, and is now used at every plant throughout the country, viz., the reduction furnace belonging to Electro-Metals, Ltd.

The process has now been developed further in Sweden so that the molten pig is delivered direct to the open-hearth furnaces, heated by the gases from the reduction furnace, and, finally, the charge from the open-hearth furnace is poured into an electric refining furnace, and the final steel is of remarkably high quality. This is obviously the right method where electric current can be obtained at a reasonable price.

In this connection it will interest you to know that electric refining of steel has gained much ground during the war in this country (Great Britain). Some forty furnaces of varying capacity have been put in—most of them in the Sheffield district, but also in other parts of the country—and the success has everywhere been conspicuous. Not only is the quality of the steel such as could only be obtained previously in crucibles, but makers have found that in spite of the high price which they pay for current (approximately 1.5 cents per kilowatt-hour), there is no doubt that electric refining offers an extremely convenient and reliable method of dealing with impurities and determining a desired analysis of the steel. Any large electrothermic iron works on the Pacific Coast would be complete only with final electric refining as indicated above.

J. O. BOVING.

Boving & Co.,
London, W. C., England

Red-Hot Summer-Day Inventions

To the Editor of Metallurgical & Chemical Engineering

Sir—The man with a chemical past went to the Chemists' Club for luncheon. At a table in the Julep Garden sat three men at meat, a man of research, his assistant and a professor of physics. "Sit down at our table," said the man of research; "we are having an invention bee and we want you to help us. I am doing my bit for preparedness and my invention relates to ordnance, of course for purposes of defence."

"What is it?" asked the man with a chemical past.

"It is a gun," said the research man, "a four-foot gun. I mean four feet in diameter. You see, the trouble with the big guns of the present is that they are fired at an angle of thirty-five degrees and the projectile meets resistance from the air throughout its entire trajectory. With my bigger gun it will be possible to shoot at a much greater angle, and, given enough explosive force, when the projectile reaches a distance of eight miles above the earth, the air friction will become negligible, so the distance may be increased in proportion to the charge. Of course, to resist a force of such violence an extraordinary density of material will be required, and I have concluded that this may be obtained at very low temperatures. To meet this I propose the use of liquid air, and for a metal I have chosen mercury."

"Details to be worked out, I suppose," suggested the professor of physics.

"Certainly," answered the man of research. "I claim for my invention sufficient tensile strength to meet the requirements. I am only worried by two features: one is how to rifle the bore and the other is the nature of the projectile."

"Why don't you use a squirrel-cage device to twist your projectile around lickety-split before you fire her off?" asked the professor of physics.

"My hearty thanks, dear colleague," answered the man of research. "Your suggestion is gratefully accepted. It is merely a problem in engineering. We may count that feature as settled. Then, you observe, having shot off a few projectiles, it may be desirable to let fly at the enemy from another point. The thing to do is to surprise him. So I plan to run the mercury by pipe line to the next best place, set up the big gun again by means of liquid air, adjust the squirrel-cage device to give the proper twist, and annihilate the re-

serves. Everything is ready to work out except the projectile; I don't know what to fill it with."

"May I come in on this?" asked the man with a chemical past.

"Why not?" replied the research man. "This is welfare work, and every suggestion is acceptable."

"Well, I've been seeking immortality for over fifty years and haven't found it yet. Here is my chance. Fill 'em with mercaptan."

"Good!" exclaimed the research man. "I accept your proposal and shall fill the projectiles as you say. Now, I think we have the whole problem of preparedness settled, with my gun, your squirrel-cage twister and your mercaptan projectile."

"I feel that there is something more important than preparedness," said the professor of physics. "I want to meet public opinion. Preparedness is only a feature of public opinion. What is universally in the public mind is the desire for a Place in the Sun. That is something that everybody and every nation wants. My invention will endeavor to meet this desire. It recognizes the great water power of the United States, only a small fraction of which is used. I propose to harness all the waterfalls, develop every one of them, and have available to be connected with each one to the full capacity of its power, a great gyroscope, or series of them. These shall all be connected with a central control station. You may go ahead with your preparedness and have as many soldiers and guns as you please, but some nation is always sure to have more of them than we have. Remember that we always have Congress at Washington, and while Congress may be active and enduring in speech, it has never yet been intelligent. At least it has not in this generation. So I plan to have these gyroscopes connected up with the State Department in Washington. Then let us suppose that we have a point at issue with some European capital. An ultimatum is given to us to do as the authorities at the foreign capital require within twenty-four or forty-eight hours, or suffer the consequences. They proceed to mobilize, and still we are indisposed to do as we are told. It is possible for nations to feel that way. Very well, as the time set in the ultimatum draws to a close and we have not obeyed, the wise man who will then be in the State Department turns a little lever, the gyroscopes all begin to turn, the mathematically computed push is given in just the proper direction, the gyroscopes push the other way, harder and harder, exactly as planned, and straightway the earth proceeds to revolve on a new axis, and London or Berlin or any other capital that gets too gay—becomes the North Pole! As soon as the ultimatum is withdrawn, another little turn of the lever brings every country back to its accustomed climate again. In time, of course, the whole world would join in the gyroscopic control of the axis of the earth, and the North Pole dip would be used for the punishment of recalcitrant nations that want to go to war when they shouldn't. It would be a great convenience, also. For instance, after the harvests are over the people of Ontario and the Middle Western States want ice for their season's store. So they send in a petition, the Great Lakes are put at the North Pole over night, and there's ice enough for everybody."

The assistant of the research man, being young in years, declared that he had no interest in public welfare, and was resolved thenceforth to live a life of sin and iniquity.

"Tut, tut!" said his principal, "what unholy thoughts are possessing you?"

"I was raised orthodox," said he, "and I stick to it, with all the fire and brimstone that's in the catechism. And I have concluded to multiply my sins and to land in

limbo. With the great heat available I expect to develop a considerable power plant. This will enable me to operate a refrigerating apparatus large enough to provide an equable temperature for my own apartment. The power plant will also serve to drive an electric generator, and this will enable me to bring down the sulphur fumes by the Cottrell method of electric precipitation. With the air thus cleared and the temperature regulated, I look forward to an enviable measure of comfort in hell."

"Just let me know," said the man of research, "when this life of sin and iniquity is to begin for the sake of order in the laboratory, and, by George, we'd better be getting there as fast as we can. We have those determinations to start, you know." The others also had work in hand and so, *exceunt omnes*, into the work-day world, where tasks are set and invention bees are discouraged.

PETER TEN BROECK.

Coming Meetings and Events

American Institute of Metals and American Foundrymen's Association, Foundrymen's Convention, Cleveland, Sept. 11-16.

American Institute of Mining Engineers, Arizona, Sept. 18-23.

Association of Iron and Steel Electrical Engineers, Chicago, Sept. 18-22.

American Peat Society, Washington, D. C., Sept. 21-23.

Mining and Metallurgical Society of America, New York Section, New York, Sept. 21.

Second National Exposition of Chemical Industries, New York, Sept. 25-30.

American Chemical Society, New York, Sept. 25-30.

American Electrochemical Society, New York, Sept. 28-30.

Technical Section, American Paper and Pulp Association, New York, Sept. 25-30.

American Gas Institute, Chicago, Oct. 17-20.

American Society of Mechanical Engineers, New York, Dec. 5-8.

American Institute of Chemical Engineers, New York, Jan. 10-13, 1917.

Edinburgh Meeting of Society of Chemical Industry

The thirty-fifth annual general meeting of the Society of Chemical Industry was held in Edinburgh, Scotland, at the University of Edinburgh, July 19 to 21, 1916, and was devoted to a discussion of the progress of British chemical industries since the war. The Lord Provost of Edinburgh, Sir Robert Inches, welcomed the society to Edinburgh, and recalled the first meeting which the society held in Edinburgh in 1894. The president of the society, Dr. Charles Carpenter, then replied and took the chair. The report of the council was read, giving a review of the meetings of various committees and of the work done during the previous year.

Doctor Carpenter, in his presidential address, expressed his appreciation of the Edinburgh section, the youngest section of the society. He said the "Athens of the North" claimed homage essentially as an ancient seat of learning, a more congenial soil for the study of *belles-lettres* than for researches in dyestuffs. If art and science mutually need inspiration from each other, the meeting in Edinburgh cannot but be fruitful in

good results. The president made a strong plea for a closer relation between science and industry. He urged upon the University of Edinburgh the necessity of placing science in the forefront of its teaching, and thus setting an example to other similar large universities. Engineering and chemistry should go hand in hand to successfully develop chemical industries. The worker also should be given consideration, and profit-sharing plans make for a higher efficiency. Education of the law-makers was also urged, and the establishment of chairs of organic and inorganic chemistry at all universities, new and old. He spoke of the value of chemical meetings, and suggested the building of a permanent meeting house, to contain library, laboratory, etc.

The medal of the society was presented by the president to Mr. C. F. Cross for his services to chemical industry, especially cellulose and paper. During the meeting there was an exhibition of dyes, glass, porcelain, etc., indicating progress made in manufacturing since the war. It was decided to accept the invitation to hold the next meeting at Birmingham.

The following papers were presented:

Fuel Economy: A National Policy Required, by Henry E. Armstrong.

Recent Improvements in By-Product Coke Over Practice, by G. P. Lishman.

Waste in Coal Production, by Henry Louis.

The Shale Oil Industry, by D. R. Steuart.

The Influence of the European War on the Tar Distillation Industry, by W. H. Coleman.

The Extraction of Tar Fog from Hot Gas, by G. T. Purves.

The British Coal Tar Color Industry and Its Difficulties in War Time, by C. M. Whittaker.

The Production of Alkaloids, as Affected by the War, by D. B. Dott.

The Manufacture of Synthetic Medicinal Chemicals as Affected by the War, by Francis H. Carr.

The Manufacture of Fine Chemicals in Relation to British Chemical Industry, by C. A. Hill and T. D. Morson.

The Paper Mill Chemist in War Time, by J. F. Briggs.

The Overhauling of Our Patent Law, by J. W. Gordon.

The Influence of Patent Law Upon Industry, by Walter F. Reid.

The Disadvantage of the Present Patent Law, by W. P. Thompson.

The Progress of the British Rare Earth Industry During the War, by Sidney J. Johnstone.

The Iron and Steel Market

The steel market has continued to make progress toward a still stronger and more active condition. The \$2 a ton advance in bars, plates and shapes made by the Carnegie Steel Company early in August has been followed by all other producers and the market is now on the higher level. For a month that is normally very dull August has done quite well in the matter of new bookings, as the contract obligations written are substantially equal to the shipments. The Steel Corporation's unfilled obligations decreased by 297,340 tons during June, but by only 46,866 tons during July, and the preponderating prediction is that a slight increase will be shown for August.

There has been no excitement in the steel market in the past fortnight, the surface appearance being one of dullness, but tonnage has been booked nevertheless. There has been an export demand greater than could be satisfied as all the deliveries desired could not be compassed by the mills, and some of the domestic consuming trades have been free buyers. The automobile trade has been particularly conspicuous in urging that

contracts for deliveries over the first half of 1917 be accepted at once, even though the price might be left open. Assurance of delivery is the prime consideration in this trade. The agricultural implement makers, by way of contrast, have been very conservative in the matter of buying and insist that if steel prices are maintained at their present high level the demand for their product will be greatly reduced.

The report of the Bridge Builders' and Structural Society shows that bookings of fabricated steel contracts in July represented only 47½ per cent of a month's capacity, the smallest percentage reported since February, 1916. Freight car orders have been extremely light. The outstanding feature of the situation is the difficulty in determining how the pressure on the steel mills can be so great when several lines of consumption are decidedly slack.

Averaging the entire period July and August and the entire steel industry there has been hotter weather than in any preceding season since there was a steel industry of any proportions. The weather moreover has had an unusually great effect in cutting down production. The steel mills are but scantily manned at best and as the men are prosperous there has been more disposition to quit work when the temperature was disagreeable. The production of steel in the two months has probably been more than 10 per cent less than the production in the two months preceding.

The Scarcity of Unfinished Steel

A striking feature of the steel situation has been the extreme scarcity of unfinished steel. The billet and sheet bar market has pursued its own course. It increased in strength in 1915 and in the first four months of this year quite in keeping with the developments in finished steel products, but in May it turned somewhat soft and in June there were offerings that were absorbed with such difficulty that the market turned distinctly soft and prices became notably lower. In July there was some buying in the domestic market, but not a great deal, and there was a moderately heavy export demand. There was continued heavy demand for shell steel, the buying being continued for a much longer period than had been expected. Early in August unfinished steel was suddenly found to be very scarce and the mills practically withdrew from the market. Excited canvasses have been made for steel by both domestic and foreign buyers and in the past fortnight the conviction has been reached that there is practically no soft steel offered, irrespective of price, for any delivery during the remainder of the year. Billets and sheet bars are quotable at \$45 to \$50 but the quotations are nominal. Occasional buyers who have influence and trade connections may be able to secure steel but the average buyer cannot make a purchase. The market has accordingly turned very quiet.

The condition as to unfinished steel is not an ordinary market one, there being no proper relation between unfinished and finished steel. Current prices for billets and merchant bars, sheet bars and light gage sheets, do not represent spreads equal to the actual mill cost of conversion. There would be a greater profit to the steel mill in selling billets instead of merchant bars, or sheet bars instead of light gage sheets. Apparently the reason the unfinished steel is not sold instead is that the mills wish to hold their custom and must hold their organizations. If finishing operations are curtailed the men seek employment elsewhere and they could not be replaced until the next depression comes.

Pig Iron More Active

During the past fortnight the pig iron market has come to life. Several fair sized lots of Bessemer and

basic iron have been bought by large steel works, while there has been well distributed buying of foundry and malleable. The buying has been done very quietly, few general inquiries being put out, and the market has been more active than appeared from surface indications. Apparently the buyers feared that higher prices would come to prevail if more interest were shown and as prices have been well established it has not been necessary to depend upon competitive bidding to secure the lowest quotation available. It is characteristic of the pig iron market that general buying movements frequently start in August, and the only explanation for such a development in a month that is regarded in general as a dull one marketwise is that many buyers desire to get under cover before an expected rise occurs. No shortage of pig iron can be regarded as having been developed in the past two months, for while furnace outputs have been reduced by the humidity the consumption by steel mills has been reduced in greater ratio. For the future, however, the majority opinion is that pig iron is destined to grow scarcer as there is little new furnace construction while steel making capacity is being constantly increased. Pig iron prices are substantially unchanged, and indeed there has been scarcely any fluctuation since the first of the year.

While iron ore shipments down the lakes have been heavy thus far this season, fully as heavy as the highest estimates indicated, there are doubts whether the movement can continue of the same proportions. The strike of dock laborers at the head of the lakes has been settled, but the Mesabi range strike continues. Production by the underground mines is only a few per cent of capacity and Mesabi range shipments are from the open pits and from stock piles. The stock piles will hardly stand the drain to the end of the season and in some quarters the suggestion is even made that all-rail shipments may be necessary in the winter. There is demand for ore for puddling and open-hearth furnace use and occasional sales are made at premiums above the regular season prices. Some interest is already being manifested in ore for 1917 and there is talk among ore producers of advancing prices about a dollar a ton, following the advances for the present season of 70 cents on old range and 75 cents on Mesabi ores.

Non-Ferrous Metal Market

Aug. 29.—Most of the metals have become stronger during the last two weeks as the result of renewed buying, especially in copper.

Copper.—Buying by domestic consumers has made a strong market during the last two weeks and Lake and electrolytic are quoted at 27.50c. for September and October delivery. November and December is quoted at 27 to 27.25c., with January and February about 1/2c. lower. Present smelter production is estimated at from 200,000,000 to 250,000,000 lb. per month. Refinery production is somewhat less. The consumption demand in this country has lately been increasing, and is expected to grow still more. Exports up to Aug. 25 were 25,205 tons of 2240 lb.

Tin.—The tin market has not been so active as some of the others, but has had a strong undertone. Deliveries for September, October and November are hard to obtain, owing to uncertainties regarding permits. Spot tin is quoted at 38.75, with futures for next year selling at 38.25 and higher.

Lead.—Considerable strength has been evidenced in the lead market, due to local and Canadian buying. Foreign buying has not been strong, as the foreign governments are said to be well covered. The Trust price has been put back to 6.50c. New York by two

advances, one on Aug. 17 and one on Aug. 18, and independents are asking 1/4c. higher than this price.

Spelter.—The situation in spelter at present is quiet and easy. About a week ago considerable buying for export created a strong market, but since then there has been a reaction. Prompt spelter is quoted at 9.30 to 9.55c., with fourth quarter at 8.75 to 9.00. The first of the five units of the new electrolytic zinc refinery at Anaconda is completed and ready for operation. The total capacity will be 70,000,000 lb. per annum.

Other Metals.—There was considerable buying of antimony a week ago, but at present the market is dull, with Chinese and Japanese quoted at 13.25 to 13.75c. Aluminium is quoted at 61c., magnesium at \$3.75 per pound, quicksilver at \$75.00 per flask, platinum at \$60.00 per ounce, and silver at 66 1/4.

Notes on Metallurgical and Chemical Engineering in Great Britain

By our London Correspondent.

Since your issue of April 15, in which a short review of the industrial situation in Great Britain was given, probably the most outstanding feature in the industrial situation is that of the further gradual withdrawal of labor consequent on the calling up of larger groups of men for military service.

Speaking broadly this has been done without disturbance of output, the employment of female labor wherever possible permitting of the change without affecting the general situation.

The abandonment of the Whitsuntide holiday was accepted by the industrial classes in a praiseworthy manner, and a considerable saving thereby effected.

Production of machinery for what may be termed private purposes (*i.e.*, not connected with the war) has not come to a standstill, the cessation of orders being governed as much by waiting on the general situation as by the necessity of standing aside for more urgent work. The withdrawal of labor is probably felt more deeply by the building trades and those dependent on local carriage of goods, such as laundries and small retailers; it is not noticeable in engineering factories. At a pinch there are large numbers of men over military age, and youths just approaching it, who would be willing to undertake work required to set free specialized labor for any purpose of national importance.

The graduated movements of prices in the commodities on the open market is a satisfactory feature.

Attention is continually being drawn to the loss to the community of coal products by the burning of the coal in beehive ovens. Sir William Garforth in his Presidential address to the Institute of Mining Engineers, dwelt upon the need for investigation into this loss. On a conservative estimate 70,000 tons of ammonium sulphate and 12 to 15 million gallons of benzol, as well as tar, could be saved if the coal were distilled in retort ovens. The general interest directed in the direction of saving coal and coal products is a most encouraging symptom at the present time.

Bearing upon the artificial manure question, the Sulphate of Ammonia Association recently gave some interesting figures from an article in the *Frankfurter Handelsblatt* of May 29th. The Association does not, of course, vouch for the accuracy of the estimates, and considers one or two of the statements to be obviously exaggerated. The article, however, apart from this, is of interest to those who can weigh its statements. A table is first given showing the increase in consumption of nitrate of soda in Germany from 55,000 tons in 1880 to 747,000 tons in 1913. By degrees the imported ar-

ticle has been superseded by sulphate of ammonia, of which 460,000 tons were used in 1913, as against 750,000 tons of nitrate of soda. In order to have a supply of artificial manure nearer than Norway the Badische Aniline and Soda works, unable through lack of water-power to manufacture by the Norwegian process, started a process of their own, called after its originator the Haber process. Production rose from 30,000 tons in 1913 to 60,000 in 1914, and 150,000 tons by the middle of 1916. The production from 1916 onwards is estimated at 300,000 tons. The article further assumes that this output can be increased to 500,000 tons, a quantity equal to the value as manure of the nitrate of soda formerly imported.

The various results supposed to follow on the above by the writers of the article do not seem to be affected by problems of carriage and distribution.

The meeting of the British Association will be for the week following September 5, at Newcastle. The President-Elect is Sir Arthur Evans, F.R.S., who will preside over the Engineering Section.

A valuable paper was recently contributed to the proceedings of the Faraday Society by Mr. Z. Jeffries of Cleveland, Ohio, on "Grain Size Measurements in Metals and the Importance of Such Information."

* * *

Some curious fluctuations have taken place in the prices of metals during the period March-April-May. Tin in comparison with its usual habits, may be said to have been the least active. Starting early in March at £184 it climbed pretty speedily (only two slight drops) to £202 on the 28th. It then dropped to £198 by May 4, and, turning, rose rapidly to £205 on the 8th. Then came a rapid drop of £7 in four days, since which the tendency has been downward, till £187 was reached on May 31.

Considering that the fluctuations on this metal have been confined to £21 or, say 10 per cent, there seems to be nothing sensational about it. Probably the price is so near the top as to have a steadying effect.

Copper on the other hand has shown a remarkable rise in price. Starting in March at a high price £106, it dropped on the order prohibiting speculative dealings in metals of vital importance to £96 by the 9th. Recovering, however, it ran up to nearly £119 in under a fortnight, then lost £4, and ultimately settled down to a steady rise to over £145 on May 17. A rapid drop followed which had landed it at £122 by the end of the month. The total fluctuation was therefore £40, or something like 50 per cent on the normal price.

Lead has also been very active. Even at the extraordinary price of £34 with which it commenced in March, it rose to £36 by the 21st, and only had one drop, to £33 on April 5. A downward tendency commenced about the middle of April, however, which became more pronounced in May, and the metal closed at £32.

Scotch Pig and Cleveland both rose till the middle of April, when Scotch stood at 104/- and Cleveland at 96/-. The end of May saw them at 88/- and 82/- respectively.

Hematite, however, went up and remained up, being quoted throughout March at 115/- and assuming in April a nominal price of 122/-.

Quicksilver was quite steady all through, about £17 per bottle.

* * *

Signor Marconi's promise of a newly invented method of preventing collision at sea shows how the inventive mind may be engaged in its usual activities even when one would suppose it to be sufficiently loaded by the pre-occupation and urgent needs of present circumstances. While awaiting with interest the description of the apparatus it may be recalled that Professor Joby has al-

ready worked out one method which he described in his book on the subject of Marine Signalling. For shore use this method depends on the transmission of two signals, a sound and a wireless one.

The difference in the time of receiving was the basis from which knowledge of position was worked out. The collision safeguard appeared to be liable to confusion in crowded waters.

* * *

Reference was made to the export of nitrate of soda from the Norwegian fixation factories in a lecture by Mr. E. Kilburn Scott at Birmingham on June 15. He pointed out the need of stimulating the production of ammonia nitrate, and the method by which this might be accomplished.

* * *

The possibility of a shortage of copper in Central Europe inducing a large consumption of Aluminium for Electrical purposes makes a recent article in *L'Information* on the comparative outputs of the metal especially interesting. The writer estimates the combined output of works belonging to England and France at 28,000 tons per annum, and Italy 3000 tons, against 22,000 tons for Germany and Austria. Among the former are deposits at Straun in Iceland and the British Aluminium Company's sources of supply at Glenravel. France has mineral deposits at Bouches du Rhone and the Var. Germany only possesses deposits in Hessen-Nassau, the quality of which does not appear to be up to standard, but these are, of course, supplemented by Austria with products from Styria and Carniola, as well as at Prechora. Previous to the war the Germans had, apparently, been acquiring interests in a company for working the French deposits, but this company has since been placed under sequestration.

* * *

The tendency of investigation in any science to split itself into a number of different branches is again exemplified by the information gained in the study of X-rays. At the meeting of the Roentgen Society on June 6, Prof. J. W. Nicholson read a paper on homogeneity of visible radiation, in the discussion on which Major Robert Wilson pointed out that different results could be obtained by the use of rays obtained from high tension transformers than by the use of the static machine.

Dr. G. W. Kaye, going further into the subject, gave examples showing the lack of homogeneity in X-rays, which appears to open up a very large field for investigation.

* * *

Among the Societies passing resolutions for the exclusion from membership of enemy aliens are the Institution of Electrical Engineers, and the Chemical Society.

MARKET PRICES
June, 1916

	£	s	d
Borax, Brit. refined (crystal), cwt.	1	10	0
Copper sulphate, ton	53	0	0
Elegant red lb.	2	0	0
India-rubber, Para fine, lb.	2	6	5
Mica, original cases, medium	1	6	0
Quicksilver (Spanish), bottle	15	0	0
Scheemmanite, ton	75	0	0
Snellite, cwt.	1	15	0
Nitrate of soda, refined, ton	18	15	0

Copper opened at £121 and rose to £124 on the 5th, thence easier to £107 on the 20th, and £103 on the 26th.

Tin opened £189 and continued down to £183 on the 6th, then recovered to £187.15 on the 9th, but dropped again, reaching £177 on the 20th, and £173.10 on the 26th.

Lead opened £33 and hardened to £33.5, but dropped from the 9th to £32.5 on the 16th, and £30.15 on the 26th.

Cleveland has been 82/6 for home consumption and 100/- for export throughout the month.

Hematite.—No prices available.

Scotch Pig.—122/6 Home, 140/- export.

Second National Exposition of Chemical Industries

The managers of the Second National Exposition of Chemical Industries, to be held at the Grand Central Palace, during the week of Sept. 25, report that most of the space on the second floor has been taken.

To meet the requirements of the societies who will hold meetings at the Grand Central Palace the auditorium has had to be increased in size, so that now it will comfortably seat five hundred persons. An automatic motion-picture machine of the latest design will be used to display the motion pictures, many of which will be loaned by exhibitors. In many cases there will be lecturers to take the audience through a pictorial tour of a plant, and they will be shown machinery and processes in the manufacture of materials. Many of the films are at present being made, and are expected to be finished in time to be shown at the Exposition. A few of these films are as follows:

Making of Black Powder.
Manufacture of Iron.
Manufacture of Fertilizers.
Mining and Manufacturing of Iron.
Manufacturing of Silk.
Making of Blotting Paper.
Silver Mining.
Manufacturing of Varnish.
Asphalt.

Two other features of the Exposition that have been added this year are a large section showing the opportunities that await the chemist in our South, and known as the "Southern Opportunity Section," and a section for the "Paper and Pulp Industry," composed of materials and machinery used in the manufacture of paper and other related products.

The "Southern Opportunity Section" was formed to display to our chemists, chemical engineers and capitalists the great latent wealth that awaits them in the undeveloped resources of the South.

The Bureau of Mines is preparing an elaborate exhibit that will cover much space; it will be a working exhibit, one where the visitor can see actual operations being carried on.

The members of the American Chemical Society and the American Electrochemical Society who register with their societies will receive badges. These will admit them to the exposition without further tickets.

The following list comprises concerns which have taken space at the Exposition up to the time of going to press:

Abbe Engineering Company
Abbe, Paul O.
American Chemical Society
American Electrochemical Society
American Coal & By-Products Coke Company
American Institute of Mining Engineers
Angel & Company, H. Reeve
Badger & Sons Company, E. B.
Baker, J. T., Chemical Company
Barrett Company, The
Bausch & Lomb Optical Company
Benzol Products Company
Bethlehem Foundry & Machine Company
Boston Artificial Leather Company
Brown Instrument Company
Buffalo Foundry & Machine Company
Carborundum Company
Carrier Engineering Company
Celluloid Zapon Company
Codd Company, E. J.
Condensite Company of America
De Laval Separator Company
Detroit Range Boiler Company
Devine Company, J. P.
Dorr Company

Drexel Chemical Company
Dreyer-Harris-Wood Company
DuPont, E. I., De Nemours Company.
Dunham Chemical Company
Edison, Thomas A.
Eimer & Amend
Electro Bleaching Gas Company
Elyria Enamelled Products Company
Foots Mineral Company
Freeport Sulphur Company
Geissinger Regulator Company
General Bakelite Company
General Chemical Company
German-American Stoneware Company
Glens Falls Machine Works
Great Western Power Company
Greiner Company, Emil
Hardinge-Conical Mill Company
Herold China & Pottery Company
Huff Electrostatic Separator Company
International Equipment Company
International Filtration Corporation
International Glass Company
Kieselguhr Company of America
Koppers Company, H.
Koven & Bro., L. O.
Laboratory Supply Company
Lead Lined Iron Pipe Company
Leeds & Northrup Company
Lenz & Naumann, Inc.
Little, Arthur D., Inc.—Boston
Little, Arthur D., Ltd.—Montreal
Lungwitz, Emil E.
Luzerne Rubber Company
Marden, Orth & Hastings Company
Merck & Company
Metallurgical & Chemical Engineering.
Monsanto Chemical Works
Mott, J. L., Iron Works
Multi-Metal Sep. Screen Company
National Aniline & Chemical Company.
National Gum & Mica Company
Niagara Alkali Company
Norton Company
Ohio Pottery Company
Palo Company, The
Patterson-Allen Engineering Company
Ptaudler Company
Precision Instrument Company
Raritan Copper Works
Raymond Bros. Impact Pulverizer Company
Research Corporation
Ruggles-Coles Engineering Company
Schaeffer & Budenberg Manufacturing Company
Schaum & Uhlinger, Inc.
Schutte & Koerting
Scott & Company, Ernest
Scientific Materials Company
Smet-Solvay Company
Sharpley Specialty Company
Sidio Company of America
Solvay Process Company
Sowers Manufacturing Company
Squibb & Sons, E. R.
Stamford Manufacturing Company
Standard Aniline Products, Inc.
Stevens-Aylsworth Company
Sturtevant Mill Company
Sweetland Filter Press Company
Swenson Evaporator Company
Taylor Instrument Company
Technical Association of Paper & Pulp Industry
Tennessee Power Company
Thermal Syndicate, Ltd.
Thwing Instrument Company
Toch Brothers
Toihurst Machine Works
Uehling Instrument Company
Union Sulphur Company
United Lead Company
United States Smelting Company
Valley Iron Works
Weiller Manufacturing Company
Werner & Meiderer Company
West Pulverizer Machine Company
Williams Patent Crusher & Pulverizer Company
Zaremba Company

American Transformer Company
American Synthetic Color Company
Alberene Stone Company
Barber Asphalt Paving Company
Wm. Beckers Aniline & Chemical Works
The Bristol Company
Bureau of Mines
Central Foundry Company
Chemical Catalog Company
Chemical Company of America
Coatesville Boiler Works
Corning Glass Works
Cisner Electrolytic Alkali Works
J. H. Day Company
Denver Fire Clay Company
Downtown Manufacturing Company
Electro Chemical Company
Electron Chemical Company
The Foxboro Company
General Electric Company
Harrison Bros. Company
Frank Hemingway Corporation
Hooker Electrochemical Company
F. C. Huyck & Sons
Krebs Pigment & Color Company
F. Kleinschmidt & Company
Life Saving Devices Company
Lehigh Car Wheel & Axle Works
Manufacturers' Record
Mathieson Alkali Works
Mine & Smelter Supply Company

Mississippi River Power Company
 Nash Engineering Company
 Nitrogen Products Company
 Newport Chemical Works, Inc.
 Paper, Inc.
 Paper Trade Journal
 Pennsylvania Salt Manufacturing Company
 Process Engineers, Ltd.
 Pyroelectric Instrument Company
 Roessler & Hasslacher Chemical Company
 Seydel Manufacturing Company
 Stone & Webster Engineering Corporation
 Shriver & Company, T.
 Swiss Colours Company
 Stuart & Peterson Company
 Society of Chemical Industry
 United Gas Improvement Company
 U. S. Standard Chemical Works

New York Meeting of American Electrochemical Society

The thirtieth general meeting of the American Electrochemical Society which will be held in conjunction with the Exposition of Chemical Industries during the week of September 25 to 30, will be opened on Thursday, Sept. 28, with the "Made in America" technical session. The complete program of technical and business meetings and of entertainment features will be given in our next issue. The ladies' entertainment features will be found in the adjoining program of the ladies' committee. Members of the Electrochemical Society will register at the Society's booth at the Exposition. The complimentary smoker on Thursday evening and the joint banquet on Friday evening with the American Chemical Society and Technical Association of the Paper & Pulp Industry promise to be real live entertainment features. Other entertainment features will be announced later, together with the complete technical program.

Program of Ladies' Committee of American Chemical Society and American Electrochemical Society

The following program has been arranged for visiting ladies by the ladies' committee of the American Chemical Society and American Electro-Chemical Society for the New York meetings during the week of Sept. 25. The lady in charge of each event is included.

Monday and Tuesday—Welcoming the visiting ladies at the registration rooms—(Chemists' Club). Mrs. Frank Henningway.

Visiting the Chemical Industries Exposition. Mrs. Bernard C. Hesse.

Tuesday—8.00 p. m. Reception at Hotel Astor.

Wednesday—10.30 a. m. Meeting—Chemists' Club, for an automobile tour along the Hudson. Mrs. J. Merritt Matthews.

1.00 p. m. Luncheon at Longview, Hastings-on-Hudson. Return to New York 5.00 p. m. Mrs. J. Malcolm Muir.

Thursday—10.30 a. m. Meeting—Chemists' Club for a visit to Altman's and Tiffany's stores. Mrs. R. N. Shreve.

1.00 p. m. Luncheon at the Woman's City Club and at the University Club. Mrs. R. N. Shreve.

8.00 p. m. Theater party—Complimentary to visiting ladies only.

Friday—2.00 p. m. Seeing New York Yacht Party. Mrs. Charles Baskerville.

8.00 p. m. Banquet.

Saturday—Visiting Chemical Industries Exposition. Mrs. Bernard C. Hesse.

The ladies' committee, including those who have joined up to the present time is as follows: Mrs. L. H. Baekeland, in charge; Mrs. Milton C. Whitaker, Mrs. Bernhard C. Hesse, Mrs. Jerome Alexander, Mrs. Mor-

ris Loeb, Mrs. Charles Baskerville, Mrs. J. Merritt Matthews, Mrs. Parker C. McIlhiney, Mrs. Frank Hemingway, Mrs. T. B. Wagner, Mrs. Elon H. Hooker, Mrs. Charles H. Herty, Mrs. Charles L. Parsons, Mrs. Herbert R. Moody, Mrs. R. N. Shreve, Miss Leola Maars, Miss E. H. Kunz, Mrs. Maximilian Toch, Mrs. J. Malcolm Muir, Mrs. Eugene F. Roeber, Mrs. Colin G. Fink, Mrs. A. B. Marvin, Mrs. Lawrence Addicks, Miss Agnes Hasslacher, Mrs. J. V. N. Dorr.

Cleveland Meeting of American Institute of Metals

The annual meeting of the American Institute of Metals will be held in Cleveland, Sept. 11-15, together with the convention of the American Foundrymen's Association. The annual foundry exhibition will be held in the Coliseum, and indications point to a much larger exhibit than was shown at Atlantic City last year. There will be many interesting entertainment features, including a trip to the ball park Tuesday afternoon, Sept. 12, for the game between Cleveland and Detroit; a trip to Euclid Beach Park Tuesday evening in special cars, tickets being furnished to all concessions; an inspection trip Wednesday afternoon to the Cleveland Furnace Company's blast-furnace plant on the Cuyahoga River flats, and entertainment at Keith's Hippodrome Wednesday evening. A luncheon will be given the ladies at the Hotel Statler, and on a later day an automobile ride. The annual banquet will be held Thursday evening, at the Statler, with Irving Bachelier as one of the speakers. Plant visitation will be limited to Thursday and Friday. Arrangements have been made for the inspection of the plants of the Ferro Machine & Foundry Company, Allyne-Ryan Foundry Company and Westinghouse Electric & Mfg. Company.

Following is a list of some of the papers which will be presented:

"Reclamation of Metallics from the By-Products of Foundry and Manufacturing Plants," by A. F. Taggart.

"Method of Selling Non-Ferrous Scrap, as Pursued by a Large Producer," by J. M. Bateman.

"The Result of Joint Work of Casting and Testing the 88-10-2 Alloy by Five Foundries, Report of the Use of the Deoxidizers of Bronzes and Report on the Aspects of Bronze Failures," by various experts affiliated with the U. S. Bureau of Standards, Washington, D. C.

"Copper-Aluminum-Iron Alloys," by W. M. Corse.

"Tests on Rolled Brass Sheets Taken in the Direction of Rolling and at Right Angles to the Direction," by W. B. Price and P. H. Davidson.

"The Application of Oxy-Acetylene Welding Process in the Repair of Defective Non-Ferrous Castings," by S. W. Miller.

"Continuation of Discussion in Connection with Defective Bronze Castings in Use by the Board of Water Supply of New York City," by A. D. Flinn.

"Evolution of Die Casting Process," by Charles Pack.

"Disclosure of Blowholes by Means of X-Ray Apparatus," to be reported by testing engineers employed in laboratory D of the General Electric Company, Schenectady, N. Y.

"Aluminum Castings and Forgings," by P. E. McKinney.

"Annealing Properties of Copper," by G. W. Ceaser and G. C. Gerner.

"Metallography as Applied to Non-Ferrous Metals," by W. W. Arthur.

"Heat Treatment of German Silver," by G. C. Holder.

Rubber Vulcanization Accelerators

BY ANDREW H. KING

This is a subject now attracting considerable attention in the rubber business. The possibilities seem almost unlimited. For example, a factory which has been using the old, well-known mineral accelerators can materially increase its capacity by the use of some one or more of the new organic catalysers, such as piperidine or para-phenylenediamine.

It is common knowledge that the degree of vulcanization can be greatly influenced by a change in either time or temperature. Thus a stock which cures ordinarily in 40 minutes at 40 lb. steam pressure can be vulcanized in 25 minutes at 60 lb. This is one way to speed up production. However, the increase in working steam pressure is expensive, and sometimes quite unsatisfactory. It is far better to add from 1 to 2 per cent of some good accelerator, and properly cure the rubber at low pressure, than to run chances of injuring the nerve by high temperature. In certain instances both high temperatures and accelerators are used, as in the case of cheap molded goods, where a large production is necessary to take care of the overhead.

An accelerator is merely a catalyser. It tends to increase the velocity of the reaction between sulfur and rubber during vulcanization. For the sake of clearness, I will enumerate a few conclusions deduced from numerous observations of the catalytic effect, sometimes called "the laws of catalysis":

1. The catalyser has the same chemical composition at the end of the reaction as it had in the beginning. This statement applies to nearly all accelerators, except certain of the organic compounds which are decomposed to a more or less extent at the temperature of vulcanization.

2. A catalytic agent is incapable of starting a reaction. It can only modify the velocity.

3. Very small quantities are sufficient to transform relatively large amounts of reacting substances.

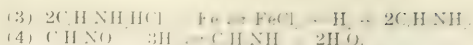
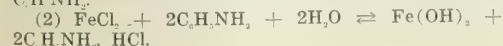
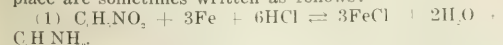
4. The final state of equilibrium is independent of the nature and quantity of a catalyst.

5. Catalysers are of two kinds—positive and negative; i.e., they may either increase or retard the reaction velocity.

The above statements are based on observed facts. Just why they are so, and what the underlying principle of catalysis is, the future may explain. There are numerous theories which seem to fit separate cases quite well. Thus, the theory of surface concentration seems an excellent explanation of the behavior of platinum sponge in the contact process for sulfuric acid.

But the separate group of vulcanization accelerators seem to belong to the intermediate product family. It is thought that the catalyser unites with one of the reacting substances, forming an unstable compound, which in turn reacts with the other substance. In the course of this reaction, the catalyser is set free, and the process begins all over again.

An example of this phenomenon, though not a catalytic action in the true sense, is found in the commercial method for the preparation of aniline. Nitrobenzene is reduced by means of iron filings and hydrochloric acid. Only about one-fortieth of the theoretical quantity of acid is necessary. This is probably because iron filings and water are able to effect the reduction in the presence of ferrous chloride. In this instance it may be called a pseudo-catalyser. The reactions taking place are sometimes written as follows:



The halogen carriers, which are so important in organic preparations, are also pseudo-catalysers.

The chemical reaction between sulfur and rubber may be written:



The speed of this reaction is influenced in proportion to the quantity of accelerator used, up to a certain limit, beyond which it acts as a retarder; that is, as a negative catalyser. As a general rule, accelerators should be used in small amounts, so as not to affect the nerve or quality of the rubber.

A peculiar fact has been noted. By a combination of accelerators the resulting increase in speed is greater than the sum of their individual increases, when acting alone. For example, the effect of 1 per cent tetramethylenediamine and 1 per cent piperidine exceeds the sum of the effects of the same catalysers when mixed in separate batches.

MINERAL ACCELERATORS

The chief mineral accelerators are:

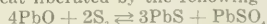
Lime
Magnesia
Litharge
White lead
Zinc oxide

They are named in the order of their relative power.

Lime: The lime in common use is prepared by burning limestone and slacking the product by means of steam. Properly prepared, it is just a little short of complete hydration. In curing soft rubber from 1/2 to 2 1/2 per cent may be used. For hard rubber larger amounts are customary.

Magnesia: The best magnesia is a heavy calcined product known as "Magnesia Usta." It is prepared by precipitating magnesium from solution in the form of magnesium carbonate and calcining the product. Magnesia finds a larger use than lime, though its curing action is only about half as great. Its advantage is that it leaves the nerve of the rubber absolutely unaffected, while lime has a slight hardening action. Combined with litharge it produces very satisfactory results.

Litharge and other lead compounds: Besides litharge, such compounds as white lead, sublimed white lead, and red lead are also valuable. Their use is limited, however, to black goods, and to those having high specific gravities. Stevens (J. Soc. Chem. Ind., 34, 524-6, 1915) is of the opinion that the catalytic effect of litharge is due to the heat liberated by the following reaction:



This effect is proportional to the quantity present, so long as there is sufficient sulfur available to properly cure the rubber, and to convert the litharge to lead sulfide and sulfate. About 1 per cent sulfur is required for every 7 per cent of litharge. At the point where the rubber is fully cured the free sulfur drops, but is never completely absent. Large amounts of litharge serve to prevent "blooming"; i.e., the coming to the surface of colloidal free sulfur in the form of a gray scum.

Red lead is more active than litharge, but should never be used because of its oxidizing tendency. White lead, that is basic lead carbonate, is also an accelerator. Compared with litharge it has a much lower specific gravity and considerable toughening action. Sublimed white lead has the following average composition:

PbSO ₄	78.5%
PbO	16.
ZnO	5.5

It has only slight curing action, but is also a good toughener.

Zinc oxide: This has but little accelerating power. As a toughener it surpasses all of the lead fillers, and is only exceeded in this respect by lamp black. Because of its slight catalytic effect, considerable quantities can be used without retarding the cure.

Miscellaneous: Some oxides have a catalytic action under special circumstances. Thus, iron oxide (3 to 8 per cent) is quite useful in batches containing brown substitute.

Golden antimony sulfide also finds considerable use. It has but small catalytic value. Its action is due mainly to free sulfur, which the technical product always contains.

Manganese oxide, MnO , and cuprous oxide, Cu_2O , are both good accelerators, but because of their marked oxidizing tendencies they cannot be used. In fact, as a general rule copper and manganese, in any form, must be kept out of rubber if the product is to be anything but worthless.

Molybdenum sesqui-oxide over 10 per cent and alkali over 3 per cent are negative accelerators. The behavior of alkali is especially interesting, owing to the extensive use of alkali shoddies. Up to $\frac{1}{2}$ per cent it acts as an accelerator. Beyond this it retards, and at 5 per cent it is almost impossible to effect a cure. Nickel oxide is a negative accelerator, and vulcanization can be entirely prevented by its use.

ORGANIC ACCELERATORS

The use of organic accelerators dates from the discovery of synthetic rubber. This product cannot be vulcanized without the addition of some of the organic catalysts. On the substitution of natural for synthetic rubber equally successful results were obtained.

The trouble with synthetic rubber, and for a time with the plantation variety, was excessive cleanliness. They secured the rubber hydrocarbon, but certain so-called impurities, which Mother Nature places in the rubber latex, were carefully excluded. Para rubber, by the Amazon method of coagulation, contains all the elements of the latex evenly distributed throughout the mass. For this very reason it is still true that no rubber is the equal of Highlands Fine Para.

The catalysts present in rubber latex are thought to be related to the proteins, perhaps decomposition products. All organic accelerators are nitrogen bearing, and many have amino groups. The function of the nitrogen seems very important. So far there are only two generalizations possible:

1. According to Dittmar, all organic bases having dissociation constants greater than 10^{-4} act as accelerators, irrespective of constitution.

2. At present only nitrogen bearing compounds are known as accelerators, and it seems that this element must be a necessity.

From a mechanical standpoint a catalyzer is most conveniently mixed when it has the following properties:

It should be a solid, capable of being very finely pulverized.

It should have a high boiling point, so as not to be vaporized during vulcanization. Such behavior would cause a spongy appearance; that is, "blowing."

For convenience I will classify the most important organic accelerators under the following heads:

1. Carbon bisulfide addition products with

- (a) Aniline
- (b) Dimethyl aniline
- (c) Tetrahydropyrrole
- (d) Dimethylamine

2. Ammonium compounds

- (a) Ammonium borate
- (b) Aldehyde ammonia
- (c) Quaternary ammonium bases

3. Amino compounds

- (a) Para-phenylenediamine
- (b) Tetramethylenediamine
- (c) Sodium amide
- (d) Naphthylene diamine
- (e) BB Dimethyl Δ methyltrimethyleneimine
- (f) Trimethylenamine
- (g) Benzylamine

4. Piperidine and derivatives

- (a) Piperidine
- (b) Methyl piperidine

5. Quinoline and derivatives

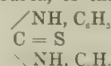
- (a) Quinoline
- (b) Quinoline sulfate
- (c) Quinisol
- (d) Sulfuroxyquinoline

6. Miscellaneous

- (a) Anthraquinone
- (b) Urea derivatives
- (c) Formanilides

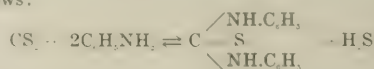
CARBON BISULFIDE ADDITION PRODUCTS

With Aniline: One of the oldest accelerators known in this country is diphenylthiourea, or thiocarbamide,



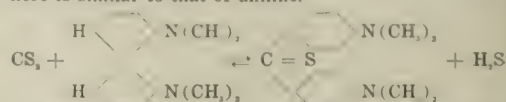
This substance may be prepared according to Gatterman as follows:

A mixture of 40 parts aniline, 50 parts carbon bisulfide, 50 parts of alcohol, and 10 parts of finely powdered potassium hydroxide are boiled gently on a water bath for three hours in a flask provided with a reflux condenser. Excess carbon bisulfide and alcohol are distilled off, and the residue treated with water. The crystals separating out are filtered off, washed first with water, then with dilute hydrochloric acid, and finally with water. To obtain the pure substance, recrystallization from alcohol is necessary. Large colorless tablets are obtained, which melt at 154 deg. C. A very satisfactory, and, in fact, a more desirable, product for use as an accelerator is secured by the substitution of sodium polysulfide Na_2S_x for caustic potash in the above reaction. A high degree of purification is unnecessary. At some factories the aniline, carbon bisulfide, and sodium polysulfide are mixed in large kettles in the open air. After a short time the whole mass solidifies. This is broken up, vacuum dried, and finely ground. A fairly satisfactory product is thus secured. The reaction taking place in this preparation may be written as follows:



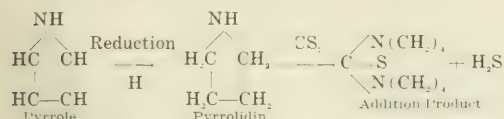
This substance is a very efficient catalyzer. It seems to do all of its work at the beginning of the reaction, so that it finds considerable use in quick curing stocks. One-half to 3 per cent is customary.

With Dimethyl Aniline: Carbon bisulfide also forms an addition product with this substance. The reaction here is similar to that of aniline.

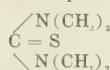


With Tetrahydropyrrole: This substance $(\text{CH}_2)_4\text{NH}$, called by the German chemists "pyrrolidin," is secured

by the reduction of pyrrole, C_4H_5N , by means of zinc dust and hydrochloric acid. Pyrrole is closely related to the proteins, and its derivatives have been isolated from protein decomposition products. The reactions for the preparation of the addition product may be indicated as follows:



With *Dimethylamine*: As would be suspected, dimethyl amine, $(\text{CH}_3)_2\text{NH}$, gives an active addition product, whose constitution may be written:



AMMONIUM COMPOUNDS

Ammonium Borate: *Ditmar* (*Gummi Zeitung*, Jan., 1915) mentions the fact that ammonium borate has a noticeable effect on the cure. This is merely of scientific interest.

Aldehyde Ammonia: This is a very satisfactory catalyser. A mixture of 100 parts Para, 10 parts sulfur, and 1 part aldehyde ammonia may be cured in 30 minutes at 45 lb. steam pressure (140 deg. C.). For comparison, a batch of 90 parts Para, 9 of sulfur, and 1 of lime requires 85 minutes at 140 deg. C.

Aldehyde ammonia, $\text{CH}_3\text{CH}(\text{OH})\text{NH}_2$, is best prepared by passing dry ammonia gas into a solution of acid aldehyde, CH_3CHO in ether. The reaction is as follows:



It is readily soluble in water, sparingly so in alcohol, and almost insoluble in ether. It melts between 70 and 80 deg. C., and sublimes without decomposition at 100 deg. C.

Quaternary Ammonium bases: These are mentioned in Bayer & Co.'s British patent 12,661 of May 22, 1914, along with aldehyde ammonia, para-phenylenediamine, sodium amide, benzylamine, and naphthylenediamine.

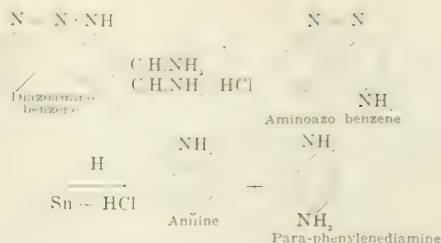
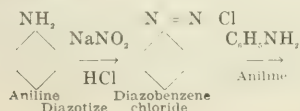
AMINO COMPOUNDS

Para-phenylenediamine: This accelerator gives good results with synthetic rubber. Bayer & Co. mention in their German patent 280,198, Jan. 1, 1914, that 100 parts isoprene rubber completely cures when mixed with 10 parts sulfur and 2 parts para-phenylenediamine and is heated in a press for 15 minutes at 45 lb. steam pressure.

Para-phenylenediamine, $\text{C}_6\text{H}_4(\text{NH}_2)_2$;  is pro-

duced by reduction of para-nitrobenzene, para-nitroaniline, or of aminoazobenzene with tin and hydrochloric acid. Other methods are: By the distillation of diamino benzoic acid. By the action of para-chloraniline on aqueous ammonia in the presence of copper salts.

Perhaps the simplest method is that for reducing aminoazobenzene. The reactions for its preparation from aniline follow:



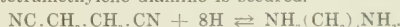
This method is the most satisfactory, and relatively cheap. Gatterman may be followed for the preparation of aminoazobenzene. After reduction, distill off the aniline with steam. The product may be purified by fractional crystallization. Pure para-phenylenediamine melts at 140 deg. C., sublimes without decomposition at 267 deg. C., is very soluble in alcohol and ether, and moderately so in water. Manganese dioxide and sulfuric acid convert it to quinone, $\text{C}_6\text{H}_4\text{O}_2$. On passing hydrogen sulfide through a solution of the chloride, and then adding ferric chloride, thionine or Lauth's violet is produced. These tests will indicate the purity of the commercial article.

It should be mentioned that para-phenylenediamine, as likewise most organic accelerators, is very poisonous, and proper precautions should be taken in every case.

Tetramethylenediamine: This substance is mentioned in French patent 464,533 by Bayer & Co. It gives very good results when the desired time of cure is rather long.

Tetramethylenediamine, $\text{NH}_2(\text{CH}_2)_4\text{NH}_2$, called sometimes putrescine, is a natural product of protein decomposition, and is produced during the putrefaction of animal matter, such as flesh.

Dimethylene bromide, $\text{Br} \cdot \text{CH}_2 \cdot \text{CH}_2 \cdot \text{Br}$, is converted by treatment with potassium cyanide to dimethylene cyanide, $\text{NC} \cdot \text{CH}_2 \cdot \text{CH}_2 \cdot \text{CN}$. On reducing this substance with sodium and boiling alcohol or by electrolytic methods, tetramethylene diamine is secured.



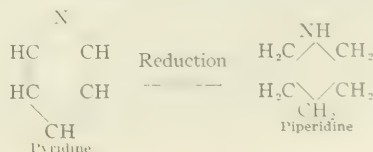
The crystals melt at 270 deg. C. and boil at 157 deg. C.

Miscellaneous Amines: Sodium amide, NaNH_2 ; naphthylenediamine, $\text{C}_{10}\text{H}_8(\text{NH}_2)_2$; trimethylene amine, $(\text{CH}_2)_3\text{N}$; benzyl amine, $\text{C}_6\text{H}_5 \cdot \text{CH}_2 \cdot \text{NH}_2$; β dimethyl Δ trimethylenimine; and nitrosodimethyl animethylamine are mentioned as having some accelerating power.

PIPERIDINE AND DERIVATIVES

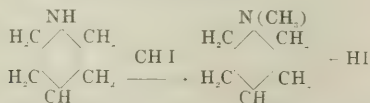
The first patent granted for an organic accelerator was to Bayer & Co. (German patent 265,221, Nov. 16, 1912) for the use of piperidine. As above mentioned, it was intended to be used with synthetic rubber, but proved so successful that it was tried with the natural variety. A mixture of 100 parts Para, 10 parts of sulfur, $\frac{1}{2}$ part piperidine, is perfectly cured on heating for 15 minutes at 53 lb. steam pressure. Without the accelerator over an hour is required. Piperidine is valuable for both hard and soft rubber articles.

Piperidine, $\text{C}_4\text{H}_9\text{NH}$, belongs to the class of secondary amines. It is a liquid smelling like pepper and ammonia. It boils at 105.7 deg. C., and has a specific gravity of .881 at 0 deg. C. It is miscible with water in all



proportions. It is best prepared by reduction from pyridine, either by use of sodium in absolute alcohol or by electrolytic methods (E. Merck, English Pat. 21,471). The reaction is as given on the preceding page.

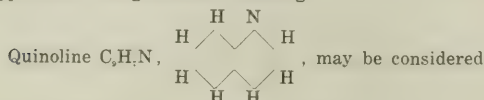
Methyl piperidine: This substance, $C_7H_{15}N(CH_3)$, is also active as a catalyst. It may be prepared by treating piperidine with methyl iodide, when the amino hydrogen is replaced by the methyl group.



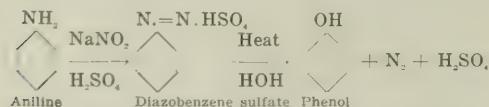
Methyl piperidine is also a liquid, and boils at 107 deg. C.

QUINOLINE AND DERIVATIVES

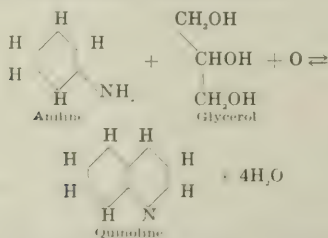
Quinoline and its derivatives are satisfactory accelerators. The amount used varies around 2 or 3 per cent. Perhaps its sulfate and quinosol find the greater application owing to ease of mixing.



as a combination of a benzene and pyridine ring. It is most satisfactorily prepared by Skraup's synthesis; to a mixture of 19 parts aniline, 12 parts nitrobenzene and 60 parts glycerol; 50 parts of concentrated sulfuric acid are added. Heat under a reflux condenser until reaction begins. Discontinue. When the energetic reaction is over, heat on the water bath for three hours. Cool, dilute with water, steam distill to remove any unchanged nitrobenzene. Make alkaline, steam distill off the liberated quinoline and any unchanged aniline. Considerable of the aniline can be removed by fractional distillation. The remainder is removed by diazotizing in sulfuric acid solution and boiling. This converts the aniline to phenol, thus:



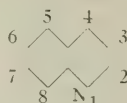
Quinoline, being a tertiary amine, is not affected. On making alkaline phenol goes into solution, and quinoline is liberated. It can now be removed by steam distillation, after which it is fractionated in order to obtain the pure substance. The reaction for the production of quinoline is sometimes written as follows:



The oxygen required is supplied by nitrobenzene in a manner not quite clear.

Quinoline, sometimes written C_9H_7N , $\begin{array}{c} CH:CH \\ | \quad | \\ N \quad CH \end{array}$ has a sp. gr. of 1.0947 at 20 deg. C. It boils at 240 deg. C., is soluble in alcohol and ether, but only sparingly so in water. It has a disagreeable, penetrating odor, a bitter, acrid taste, and on exposure to moist air is converted

to the hydrate, $C_9H_7N + 1\frac{1}{2}H_2O$. The nomenclature of quinoline derivatives is indicated by the scheme



Quinoline sulfate: This is sometimes called quinoline sulfonic acid. For this purpose the 8-acid is most commonly used. It is secured on heating with concentrated sulfuric acid at 220 to 230 deg. C. for a short time. Perhaps the potassium salt of this acid would give better results.

Hydroxy quinoline: This quinoline derivative should be valuable as an accelerator. It may be prepared by the fusion of the 8-quinoline sulfonic acid with caustic potash. It forms prismatic needles melting at 76 deg. C., and boils at 266.6 deg. C. under 752 mm. pressure. It is sparingly soluble in cold water, readily so in alcohol, and volatile with steam. Aqueous solutions of its acid and alkali salts are yellow.

Quinosol: This is 8-hydroxy quinoline, 5-sulfonic acid, and is prepared by sulfonating 8-hydroxy quinoline with cool, fuming sulfuric acid. (Claus and Posset, J. pr. Chem. 1890, 2, 41, 33). Thorpe (Dict. App. Chem. vol. IV, 471) prepares it by heating 8-hydroxy quinoline in alcoholic solution with potassium pyrosulfate, $K_2S_2O_8$. Quinosol forms small sulfur yellow needles, melting 175 to 177.50 deg. C. It is soluble in alcohol and in water.

Ditmar mentions oxyquinoline sulfide as a very satisfactory accelerator.

MISCELLANEOUS

Anthraquinone, 3 to 5 per cent is recommended for use in batches containing substitute.

Urea and such derivatives as guanidine are advised.

There are numerous patents covering the various anilides, such as formanilide, etc. Formanilide, $C_6H_5 \cdot NH \cdot CH : O$, is prepared from aniline and formic acid. On treatment with diphosphoropentasulfide, P_2S_5 , thioformanilide is produced, $C_6H_5 \cdot NH \cdot CH : S$.

Albumen: An interesting consideration is the patent of W. Esch (German patent 273,482, Nov. 22, 1912), which covers the direct addition of proteins to rubber. He first prepares a paste by mixing the protein, usually egg albumen, 15 parts, with 2 parts hydrated lime or magnesium hydroxide. This paste is mixed with the rubber, dried, sheeted, and smoked, to render the albumen insoluble. Low-grades are considerably improved.

CONCLUSION

To the casual reader this paper must appear rather rambling. I have only been able to touch the high spots in the subject of accelerators. In fact, only the high spots are known. As is customary with most great advances, the untrained investigator tries everything he can possibly think of. The theoretical man follows in his path, and adds his discoveries to the great mass of accumulated facts called "Science." The whole subject of rubber is one demanding scientific treatment. The velocity of the reaction between sulfur and rubber should be investigated more thoroughly and from the standpoint of the physical chemist. In fact, a consideration of this subject along the line of the phase rule would doubtless prove as valuable here as it did in the steel industry.

To the novice in this field patience is most necessary. No substance should be rejected until it has been tried under all possible conditions, and in all possible variations. In this, as in other lines of scientific research, the motto must always be, "Go as far as you can see, and then see how far you can go."

Commercial Considerations Concerning the Blast Furnace

BY J. E. JOHNSON, JR.

The object of operating a blast furnace is to make money. This obvious fact should not require to be stated but as a matter of fact for various reasons it is sometimes apparently forgotten by those who operate, and even more frequently by those who build blast furnaces. There seems to be a certain fascination about the business which inspires in those who are not familiar with it the desire to enter it and were this not balanced by an even more acute desire on the part of many of those who are in to get out, the business would be overcrowded worse than it is.

Under these conditions it seems desirable to set forth something of the commercial considerations which must govern in the long run, not only for the benefit of the owner or investor, but equally for the higher employees, for if the business is not fundamentally sound they will have an unhappy time and very likely lose the ultimate benefits of many years of hard work.

Location

This is a subject concerning which much has been written and sometimes without consideration of all the factors. There is probably no other large business in which freight on raw materials and finished product plays so great a part. It may be doubted whether freight is less than 25 per cent of the total cost delivered to the consumer except in a small percentage of the business, it is frequently more than 33 per cent and even 50 per cent. Under such conditions the question of location in relation to sources of raw materials and markets is vital.

In the "Engineering and Mining Journal" of March 13, 1915, I treated this subject on lines which are believed to be new, and developed the law on which the location of the industry seems to hinge, for it accounts for the facts as no other law seems to do. This article is quoted below.

"The reasons generally assigned for the location of the iron industry have dealt chiefly with the question of whether the ore, of which about two tons are required per ton of iron, should be brought to the coal, of which about $1\frac{1}{2}$ tons are required, or vice versa. The coal is frequently coked before shipment and the weight of coke required is only about one ton per ton of iron against nearly twice as much for the ore; but many plants have been located much closer to the coal than the ore, nevertheless. This fact has not unnaturally troubled many who have attempted to work out the underlying causes.

"It may be freely admitted that the location of iron-manufacturing centers is a matter of freight charges; but not, as is commonly assumed, of freight on raw material only. Obviously there must be included freight on the finished product to the point of consumption. If we were to consider the establishment of an iron works in a country entirely without such works, knew that each person would consume a given weight of iron per year, and knew also the tonnage of the proposed works, we should know how much population was required to consume the product and from the density of the population in the country we could calculate the average distance the product would have to be hauled to reach the consumer, and the freight for this haul added to the freight on the raw materials would constitute the total freight charge on the product. It is this which should be kept a minimum. It would clearly be an accident if the point which gave the lowest combined value

for the three were at either the ore mines or the coal mines.

"The correct location would obviously be the equilibrium point of the three forces acting through the coal mines and the ore mines and the center of population. We could, without much trouble, make a model which would illustrate the action almost perfectly. We need only to put a peg at the center of population on the map of a given district and one each at the ore mines and coal mines, fasten together at one end three pieces of rubber cord of equal length, whose strengths were proportional to the rate of freight per mile of the quantity of material equivalent to a ton of finished product, and attach the free ends to the corresponding pegs; the junction point would be the equilibrium point and would indicate the proper location of the plant. The strength of the forces acting is profoundly affected by the means of transportation available (whether water or rail) and the location of the equilibrium point is obviously influenced to correspond. The sum of the tensions in all three strings measures the disadvantage under which the district must labor.

"We can see this law demonstrated in the growth of our iron-producing centers. At the time of the Civil War, Pittsburgh was nearly the center of population of the country, and it made, for the next twenty years, the vast bulk of the steel produced, although there was a considerable center in eastern Pennsylvania and New Jersey, in which the fuel, the ore and the consuming population, were all close together and the sum of the tensions was small, so it prospered.

"As the West became settled, the center of population traveled West, first to Ohio, then to Indiana, and then to Illinois, where it is now; simultaneously the Chicago district developed as an iron center although its freight on ore is but little less than to Cleveland and Buffalo while its freight on coal is very much higher; but it is the center of a great consuming district, and its freight on finished product is low enough to make the sum of the string tensions small.

"Later still, Colorado became an iron-producing center, in spite of many disadvantages, because of its location near the center of a consuming district which is far removed from any other source of supply. The sum of its string tensions was high but that of any other iron-producing district is higher in its territory.

"The present construction of a steel plant in Duluth is a further example: The freight on both coal and ore assembled there has been very low for many years; but until the population of the Northwest became large enough to support railroads whose tonnage of steel consumption runs into six or seven figures, it did not pay to build a steel plant there. The freight on the finished product to points of consumption would have been too high.

"At Birmingham the conditions are similar but more marked. The ore and coal are in closer proximity than anywhere else in the known world, the tension in these two strings is almost nothing but the freight to outside consuming centers was so great as more than to counter-balance this advantage; the tension in the single string was more than that of all three at other iron-producing centers and the district made much pig iron but very little money until a local consuming center was built up.

"In the future, the attraction of the center of population will be increased even over what it is now; because the gas, which is a by-product in the production of coke, is of vast value for public heating and lighting and the power which can be produced with surplus gas from the furnace will be increasingly valuable for public utility purposes.

"These products are consumed in steel mills in greater quantity than they are produced by its coke ovens and furnaces, so such works are not to be considered as sources of supply for these products and their location will not be so strongly affected; but the merchant furnace will have gas and power for sale and will more and more be so located that it can dispose of them to good advantage without building long pipe or transmission lines; that is, near centers of population."

"That is, in the future, as we grow more efficient there should be an intimate connection between the iron blast-furnace plant and the public utility, and especially the public utility serving large centers of population."

Careful consideration of the history of the iron business in relation to its location will show that a plant must be located in harmony with this general law in order to have a chance of ultimate success. The importance of the by-product oven in relation to the location of the iron industry may well be a little more elaborated.

Large communities use gas in great quantities and are destined to use it in still greater ones as better processes make gas cheaper and so increase its great advantages for cooking and heating. Its use will also grow with the development of the mantle-light (Welsbach) with pilot flame control giving the convenience of electricity with a source of light as powerful and much more agreeable to many. The candlepower of gas, so important in the days of the open flame burner, is rapidly vanishing as an important consideration on account of the vastly greater amount of light which may be obtained even with a perfectly non-luminous gas, by means of the incandescent mantle.

The by-product oven yields a large quantity of cheap gas of low illuminating, but high calorific, power even after the recovery of the by-products from it, and on this account it is destined more and more to be the source of domestic gas, and this will mean the production in the vicinity of large communities of large quantities of metallurgical coke which being produced as a by-product, will be available at lower prices than an equal grade would command in that location under different conditions.

Where the community is large enough and is a manufacturing one a market for iron will exist and this will lead to the local production of iron in cases where it would be commercially impossible without these favorable conditions.

Construction

Granting that a suitable location has been chosen the size and construction of the plant next demand careful consideration. The most economical furnace to build and to run on the basis of cost per ton is the large furnace, 22 by 90 ft., if there be a market for its product when run continuously. On the other hand, almost any furnace run continuously makes cheaper iron than one run interruptedly, for the advantage of the large furnace has often been overestimated while the disadvantages of interrupted operation, both technically and commercially can scarcely be overestimated, and it is far better to build a furnace of moderate or even small size and keep it operating continuously, than it is to build a large one and run it intermittently. Some approximate figures of the difference in cost of operation of different sized furnaces will be given later.

When the size of furnace to suit the conditions has been decided many questions as to types of construction remain to be decided, and errors are often made in the decision apparently for lack of a guiding principle.

There is often a disregard of cost. Furnaces are built in the prevailing style whether that style was developed

for their conditions or not, and without any regard to whether some simpler or less expensive construction would answer. Gas engines are suggested for isolated furnaces with no market for surplus power. Trestles are built 40 and 50 ft. high and then no use made of the storage capacity so created. Bins are constructed so as to give only half the capacity they might have with the same expense. Elaborate coal and ash handling systems are applied to boilers that should properly be fired with gas 95 per cent of the time.

On the other hand, the directors are frequently "penny-wise and pound-foolish." In one case within my own knowledge they insisted on building a new furnace of scrap plate and using an old mantle and columns which necessitated the use of lines for the furnace absolutely unsuited to the conditions under which it had to work. The total saving as compared with building a furnace of new material suited to its work was \$10,000. The furnace never did what it was designed to do by a large percentage; the loss per year, due to bad furnace work, was probably not less than \$25,000, and at the end of a few years, due to the combination of rotten material and bad lines, the stack fell down bodily in full operation causing a loss of \$40,000 to \$60,000. Many other instances might be mentioned, none so bad perhaps as this but equally as stupid.

The simple rule by which the value of any construction may be measured is: Find what interest it will pay, indirectly as well as directly upon the investment. There are plenty of justifiable expenditures on which no direct saving can be shown. For instance, to build a modern hearth jacket with water-cooled staves inside a massive steel shell costs several thousand dollars more than to build one of some other types, and one of the latter might go through a blast without a breakout, in which case the return on the money spent for the better one would be nil. But again with the old type during a blast there might be half a dozen breakouts, each of which might cost as much as the increased cost of the safe construction, with the possibility that the explosions which frequently accompany breakouts might kill one or more men. In such a case it is not only foolish but almost criminal to refuse to make the expenditure which practically makes such things impossible.

In the matter of making expenditures to prevent objectionable occurrences which might shut down the furnace it is necessary to remember that certain charges which in operation we spread over the cost of the iron made, run on just the same when the furnace is shut down for repairs. When there is no iron being made to carry them therefore we can truthfully say, however it may sound, "We lose the labor and overhead on all the iron we don't make."

These charges on a 500-ton furnace run from \$1.25 to \$1.50 per ton, therefore, a twenty-four hour shut-down on such a furnace means a dead loss, exclusive of profits not made, of \$600 to \$750. This does not include the coke for banking and restoring the furnace to normal operation, or labor for repairs other than that of the regular crew. On this basis it is obvious that to spend \$5,000 to prevent a twenty-four-hour shut-down once a month would be a virtual necessity, whereas to spend the same sum to prevent such a shut-down once a year would be open to discussion.

Sometimes it is necessary to estimate what is the probability that a given mishap will occur and on the basis of that probability figure what expenditure is justified to eliminate the possibility of its occurrence.

When it comes to savings whose value per ton can be definitely estimated we are, of course on much surer ground. We have only to estimate the saving per year and compare the amount with the investment required.

Even here certain precautions are necessary. Such investments are not like the purchase of a bond in which the principal is secure and a low return is acceptable.

It is obvious that the return on such an improvement must not be less than that expected from the plant as a whole and as this is never less than fifteen and should be 20 per cent for so irregular a business, it is a safe rule to consider very thoroughly any proposed improvement which will not pay for itself in five years.

Costs

Before entering upon any further discussion of commercial considerations we must have a measure of commercial results of which the most important part is the cost sheet. Cost sheets for pig iron are very simple and are virtually standard. Like all other industrial cost sheets those of pig iron are made up of three items, raw materials, labor, and overhead, but unlike most other products raw materials are far and away more important than both the others put together, and overhead is larger in good plants than labor.

Owing to the fact that the cost of raw materials is fixed by conditions over which the management has no control and that the quantities of each required per ton of iron is subject only to a very limited control, there has come into use a standard of comparisons for costs which consists of the total cost minus the cost of raw materials. This is known as "net cost above materials." This embraces labor, minor supplies, lubricants, relining fund, renewal fund, insurance, taxes, etc. The whole amount varies from \$1.25 per ton for large and well run plants to \$2.25 for smaller or poorly run ones.

Labor varies from forty to sixty cents on a large mechanically handled furnace, to \$1.50 for small hand-operated furnaces. The relining fund must be such an amount that at the end of the blast it will equal two to three times the cost of brick for a new lining. Twenty cents per ton on a 500-ton furnace for a campaign of two years, or say 700 days, is \$70,000, which is about three times the cost of a lining for such a furnace. The renewal and repair fund should equal an amount in fifteen years that will rebuild the plant complete except site, as it will practically all wear out or be replaced in that time, and no profit can be properly shown until this depreciation be provided for.

A typical cost sheet without too much sub-division is shown below in Table I. It will be noted that no interest on the investment is shown. This is probably not correct accounting, but is universal practice in blast furnace costs. The fact should not be forgotten in considering the profit and loss shown by any blast furnace operation.

The Most Economical Size and Rate of Driving for Furnaces

As regards the consumption of ore and stone per ton of iron there is no difference between the smallest and the largest size of furnaces using the same material. In regard to coke it might be thought that the large furnace had the advantage due to less radiation and water cooling in proportion to its output, but as a matter of fact small furnaces working under the same conditions otherwise do as well as large ones and have often done much better. The better control of the charging due to their smaller size seems to offset the advantage of smaller heat losses from the larger ones.

We can therefore consider the cost of different-size furnaces only as affected by labor cost, interest and depreciation charges, and power cost.

It is not possible to obtain sufficient information for an absolutely correct solution of the question, but by

TABLE I—Cost Sheet for a Typical Blast Furnace, Based on 1914 Output

Items of Cost	Pounds	Rate Per Gross Ton	Cost per Ton
Ore	4,244	3.56	15.10
Cinder	122	2.77	0.56
Total ore and cinder.....	4,244		6.59
Scrap used	122	6.00	0.327
Gross metallic mixture.....	4,366		6.917
Total scrap purchased.....	115	6.00	
Net metallic mixture.....	4,251		6.609
Coke (net tons).....	3,392	3.10	3.74
Coal	1,133	0.80	.405
Limestone			
Total fuel and fluxes.....			4.145
Total materials charged.....			10.754
General superintendence.....			.082
Stocking			.067
Charging			.046
Other Producing Labor.....			.099
Labor in Repairs and Maintenance.....			.028
Material in repairs and maintenance.....			.092
Lubricants			.096
Tools, miscellaneous supplies and expense.....			.034
Tuyeres, blocks and cooling plates.....			.010
Refractories			.042
General works expense.....			.167
Blowing expense			.056
Water cost			.067
Electric light and power cost.....			.008
Yard Switching Expense.....			.112
Laboratory expense			.023
Stable expense			.008
Shop expense			.042
Casting machine expense.....			.042
Dry air cost			.050
Reserve for relining.....			.250
Reserve for contingencies.....			
Gas credit			
Total			11.830
Tons produced			76,432
Daily average production.....			618
Production since relining.....			276,739

the use of certain reasonable assumptions we can make some illuminating comparisons. In regard to labor we know that there is a certain irreducible minimum no matter how small the furnace or the tonnage produced, and that an increased tonnage does not require a proportionately increased amount of labor. For instance, the size of the cast house crew does not increase very much between 200 tons and 500 tons output. On the other hand the labor of unloading raw materials from the cars is practically proportional to the amount of raw material. The engine and boiler house crew is only one man per shift for a 100-ton plant but with water tenders, extra oilers, etc., is two or three men in a plant of 500-ton output.

Generally, we may say that the labor for any output is the irreducible minimum for minimum output and for each increase in output an additional amount which increases at a slower rate than the tonnage.

Virtually the same thing is true as to plant cost and fixed charges thereon.

To build a furnace stack of a certain size and the hoist for it, costs the same irrespective of the tonnage to be produced, while the cost of the stoves for large tonnage is more than for small, but not proportionately more. The cost of bins is, however, nearly proportionate to the tonnage to be handled. The cost of the power plant is left out entirely here, because the charges on it are included in the cost of power.

We have seen in the article on the rate of driving that it is easy to obtain a reasonable approximation to the power required to blow any furnace at a given rate and knowing this we can calculate the cost of the plant very simply at so much per horsepower, or what is simpler still, knowing by the experience of various investigators, C. J. Bacon, H. J. Freyn, etc., what is the cost of power development at furnace plants, including fixed

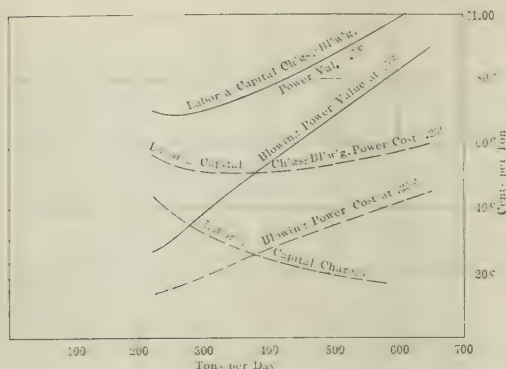


FIG. 1—EFFECT OF INCREASED PRODUCTION ON SUM OF LABOR AND CAPITAL CHARGES — COST OF POWER FOR BLOWING AT .25C. PER HP.-HOUR AND VALUE OF SAME AT 0.50C. FOR 20 X 80 FURNACE

charges, upkeep, labor, lubricants, etc., we can use figures based on their work.

We have, however, two conditions, that where there is a market for surplus power, and that where there is none. In the last case we need consider only what power costs without any allowance for the value of the gas, and in the other, what it is worth or might reasonably be sold for. I have taken $\frac{1}{4}$ cent per horsepower hour for the first, and $\frac{1}{2}$ cent for the second, the latter being a very conservative figure.

The value of the three items, labor, fixed charges and blowing cost, in cents per ton on the basis of the assumptions made is shown by Fig. 1 for a furnace 80 x 20. The first two items are of the same character, a fixed amount plus an amount increasing with, but more slowly than the tonnage, and these are therefore added together and their sum per ton of iron shown as one curve, a hyperbola descending to the right. The curves of power cost and power value ascend almost along straight lines to the right. The sum of the former and that one of the two latter which corresponds to the conditions, shows the sum of these costs for these conditions.

These have been calculated for four sizes of furnaces, 17½ ft. x 70 ft., 20 ft. x 80 ft. and 22½ ft. x 90 ft. and 25 ft. x 100 ft., both for power cost and power value.

These are plotted on a common basis of daily tonnage in Fig. 2. The solid lines show power value and the dotted lines show power cost in each case.

Several facts show forth very clearly, first, that each curve has a minimum value or point at which the furnace will produce the cheapest iron on the basis of these costs; second, that the cost of the 17½-ft. x 70-ft. furnace is hopelessly higher than that of the 20-ft. x 80-ft., but that the latter is only a little higher than that of the 22½-ft. x 90-ft., and higher than the 25 x 100-ft. by only two or three cents per ton.

In other words, the advantage of large production in lowering cost increases very slowly after the size of furnace reaches 20 x 80 and the tonnage reaches 300, if the cost of the power for blowing be given due weight.

On the other hand, it will be seen that the cost curve of the 22½-ft. x 90-ft. furnace is much flatter than that of the 20-ft. x 80-ft. and that the most economical point can be exceeded considerably with only a slight increase in cost.

The Effect of Rate of Driving on Profits

It seems likely that cost per ton may at times have received too much consideration and profit per day and per year not enough.

It is very true that during several years out of every ten most furnaces have to figure not how much profit they can make, but how small they can keep their losses, for these cannot be cut short by stopping altogether. Fixed charges of interest, taxes, insurance and some salaries run along just the same, and it pays better to run at a loss that does not exceed this amount than to shut down and break up the organization. But at such times we cannot make all the saving represented by the minimum rate over any higher rate because if we are ever to be able to run at a higher rate the investment in power plant for that rate must have been made and the fixed charges on it will go on just the same.

When we come now to the question of profits the question is not one of minimum cost per ton, but of maximum profit per day. As a general thing a furnace is not built unless its projector can see a profit of \$1.50 as a minimum for a 500-ton furnace costs with its site and all complete nearly \$1,000,000, its output is say, 170,000 tons per year, and \$1.50 per ton profit on this is \$255,000 per year; capital can be scarcely raised for a smaller return than this in so variable a business.

On the basis of the profit consider the case of the 22½-ft. x 90-ft. furnace on the "power value" basis. The minimum cost for these items is at 300 tons and is 0.65, at 500 tons it is 0.76 or \$1.1 cents higher. On this basis the \$255,000 profit per year on 170,000 tons at \$1.50 per ton would become \$1.61 per ton, on three-fifths as much 102,000 tons, or \$164,220 per year, which would naturally be less acceptable to the owner than \$255,000, even though lower costs were made.

It is very obvious from these considerations that 500 tons per day is not the limit of production from the commercial standpoint, and that it is vastly more important to be able to make double the tonnage in good times than it is to make iron for 11 cents less in bad times.

During these relatively rare periods when the profit per ton is several times \$1.50 per ton these considerations become correspondingly more powerful and the furnace must be equipped to make a maximum production during these periods even though the fixed charges during hard times are somewhat harder to carry, because in this way we secure the maximum return over a long period.

By-products

There are two important by-products from the blast furnace, the slag and the surplus gas.

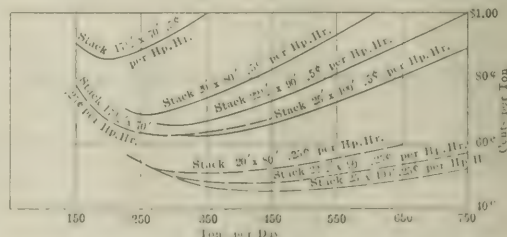


FIG. 2 IRREDUCIBLE LABOR AND BASIC CAPITAL CHARGES PLUS BLOWING POWER REQUIRED AT COST OF PRODUCTION (.25C.) AND AT SELLING VALUE (.50C.) PER HORSEPOWER-HOUR FOR FURNACE OF DIFFERENT SIZES AT DIFFERENT RATES OF PRODUCTION

SLAG

This finds utilization in three ways at the present time in this country; others are used in Europe and are under consideration here. First, as a raw material for cement manufacture; second, as aggregates for concrete; third, as filling material. In Europe it is used to make slag building brick and the heat is used to generate steam.

Blast furnace slag consists principally of the three commonest and least valuable of the components of the earth's crust, silica, alumina and lime; any attempt to utilize it, in order to succeed, must recognize this fact, especially as its composition must be regulated not by the product into which it is to be converted, but principally to suit the conditions of the furnace producing it.

BRICK

The extremely low cost of the natural raw materials for brick manufacture and the high quality of product which can be produced from them has prevented the introduction into the United States of the manufacture on any large scale of slag brick whether cast direct or made by the grinding, mixing and steaming process.

STEAM PRODUCTION FROM SLAG

A plant has been built and operated in England for the production of power from the waste heat of the slag, a project over which many inventors have dreamed.

The development of the low-pressure turbine made the realization of this dream much easier. It seemed only to be necessary to permit the slag to flow into an air-tight chamber containing a good volume of water in the bottom, maintain only enough pressure to exclude the air and utilize the steam formed by the direct action of the slag on the water in a low-pressure turbine.

It was found, however, that the acid vapors generated particularly by the sulphur in the slag ate up the blades of the turbine so rapidly that this plan was out of the question, so a boiler or evaporator was introduced, made of material unaffected by these acids and the original steam was condensed in this with the production of an equivalent amount of pure steam at a somewhat lower pressure. The slag granulated in the first vessel was continuously removed by a bucket elevator working in a sealed compartment.

The success or failure of any such operation depends upon the price of coal in the district and considering the necessarily high plant cost per horsepower of such an installation it seems inherently doubtful whether the value of the equivalent coal saved would pay the high fixed charges. No plant for the generation of power from slag is in use in the United States at this time.

SLAG CEMENT

The slag from a large percentage of the furnaces of the largest iron and steel company in the United States is converted into Portland cement. The slag is granulated by a stream of water as it flows from the furnace, the granulated material is dried, ground, mixed with ground burnt lime in correct proportions, the mixture burnt to clinker in a rotary kiln and the clinker ground to cement. The slag must not contain more than 3 per cent of magnesia in order to make good slag, so the furnaces whose slag is so used are confined to the use of calcite stone. This converts a waste material from a liability to an asset and with the increasing use of concrete the business seems certain to grow, and it is not improbable that better methods of cement manufacture from slag will some day be developed.

SLAG FOR CONCRETE

Slag broken up after being allowed to cool slowly forms excellent aggregates for concrete. Being rough

and irregular it produces an excellent bond with the cement, and unlike limestone it does *not* swell and go to pieces under the effect of fire. Its use for this purpose will grow with wider appreciation of its value.

SLAG FILLING

Slag has been used for reclaiming low land, probably from the earliest days of the blast furnace. In those times it was picked up by hand labor and hauled away cold in carts and wagons, but at present it is either flushed to place with the water used to granulate it or taken to the desired location molten in ladle cars.

When filled to a depth of several feet in the latter way it makes a very solid foundation and is much valued on water-front locations, where cheap transportation has caused the location of so many plants in recent years and where there is usually much low land which can be reclaimed by filling.

When a railroad fill or dam is desired, end dump ladles are very desirable as they build an embankment with almost vertical sides and therefore use a minimum of material to which, however, its practically monolithic structure insures great strength.

THE SURPLUS GAS

In earlier articles we have seen that with good power-plant and stove practice about one-half the gas produced by the furnace is available for other purposes after the furnace requirements have been supplied. As the gas contains about half the heat energy of the coke from which it is produced we evidently have available in such a case about 25 per cent of the energy of the coke. This means in the case of a fairly economical 500-ton furnace the heat equivalent of about 100 tons of coal per day. This is evidently an asset of no mean size even where fuel is cheap. How shall we utilize it?

The answer to this question is indissolubly bound up with that of the type of blowing engine to be adopted, already discussed in the article on blowing machinery.

When the furnace is operated in connection with steel works, as about 75 per cent of the furnace capacity is, the steel mill being a heavy consumer of power, the proper and obvious procedure is to convert the heat into power and use it in the steel mill, as is the universal practice in such cases.

The question of the best method to be followed is, however, by no means definitely settled. For those engines in the mill which are steam-driven there is, of course, only one solution, to use the gas for the production of steam, but the power used in mills is increasingly electricity and the question of how best to generate this power is a matter for discussion. The general considerations governing the matter are shown by the following quotations from a lecture before the students of Pennsylvania State College, March, 1915.

The gas engine works on a totally different principle from either the steam engine or the steam turbine and has consequently very different characteristics. It is not capable of much change in speed and its economy drops very rapidly as the load falls off, largely because the friction of the engine is very high and almost constant irrespective of the load, so that a friction of 20 per cent at full load means one of 40 per cent at half load, and so on.

This type of engine is also capable of carrying only very slight overloads, that is to say, its most economical load is its maximum load, and any overload capacity is secured only at the expense of economy and at the price of buying a larger engine. In these respects it is at a great disadvantage as compared with either the steam engine or the turbine, both of which have a large overload capacity which extends far beyond their most economical load.

On the other hand, the gas engine cuts out entirely the boiler, and above all, it has a heat consumption only about two-thirds or three-fourths of that of the best steam plants.

It was at one time supposed that this fact was destined to make the gas engine the preferred prime mover for all electric power work, but other considerations came in and this expectation has not been realized; and some of the best gas-engine men admit that where coal is the fuel used its day of realization has been indefinitely deferred.

Leaving out of consideration altogether the question of first cost and capital charges for the present, let us consider only the operation. Before coal can be used for gas engines, it must be gasified in a gas producer—an apparatus having an efficiency when delivering cold gas (which a gas engine must have) of 75 to 80 per cent, which is almost the same as that of a well-designed and operated boiler plant. So on that basis the two are even. But while coal may be burnt under boilers for a few cents a ton, say 15 cents, in large plants, it cannot be gasified for much less than 45 cents and often 50 cents.

Now the efficiencies of the producer and the boiler being almost the same, the fuel consumed will be in the same ratio as the heat consumption of the two motors themselves, say as a liberal figure 14,000 B.t.u. for the turbine, and 12,300 for the gas engine, a ratio of 1.17 to 1. Then if the coal cost is \$1.00 delivered, its cost burned under boilers is \$1.15 and gasified \$1.45. The fuel cost is proportional, therefore it is $\$1.15 \times 1.17 = \1.34 for the steam turbine and \$1.45 for the gas engine. That is, the heat units used by the gas engine are less, but the money cost of fuel is more.

This is all based on full-load conditions, and while the cost for both goes up very rapidly for light loads, owing to the far flatter heat-consumption curve of the turbine and its smaller relative size due to its much greater over-load capacity, its heat consumption rises much more slowly and as the use factor in public service work is about 30 to 40 per cent, it will be perfectly obvious that the advantage of the turbine over the gas engine will be much greater on the average than it is at maximum load, even on the heat-unit basis. Of course, as the cost of coal rises, the case becomes more favorable for the gas engine, at full load, but it is very doubtful if under any ordinary commercial conditions its practical economy on the average is much higher than that of the turbine.

When we come to the iron industry we come to a different condition, very much more favorable to the gas engine. This is that the fuel to be used is already gasified by the blast furnace, this gas being in fact almost an ideal fuel for gas engines, and they are, therefore, entirely freed from any charge or loss of heat for gasification, except that the sensible heat of the gas, 6-8 per cent in good practice, must be sacrificed to fit it for gas-engine use.

The steam plant, on the other hand, is under the necessity of burning this gas under boilers with the same losses as occur in coal firing, excepting that the labor cost is very small. In the past, the economy of furnace boilers has been extremely poor. I have tested boilers on which it was down to 30 per cent. Fifty per cent was about average practice until quite recently, but just at the present time this subject is receiving great attention and boilers are being operated at an efficiency of 75 to 80 per cent in regular operation. In this case the full-load fuel consumptions are proportional to $0.77/1.17 = 0.66$ and $(1.00-0.07) = 0.93$, or 1.41 to 1, with the further advantage that the gas engine is enabled to dispense with one whole operation and

its attendant bother, the gasification of the coal. Moreover, the gas engine has in this service a further great advantage. The use factor is about 60 per cent for electric service in the steel industry, while for blowing engines it is near 80 per cent. Why then are these engines not in universal use in such plants? Here we come to the real milk of the cocoanut.

We have hitherto said nothing of comparative labor costs and of capital charges. In regard to the former the gas engine has had a bad name. The stresses which it undergoes are tremendous, and breakdowns in the past were frequent and serious, while the uncertainty of the engine's going at all was a decided factor in its early days. But if you remember the prayerful uncertainty with which a man started out on an automobile trip ten or twelve years ago, not knowing when or how he would return, and consider our present entire disregard of this as an important factor, you will admit that many of the defects of that type of motor have been removed and that its reliability now fairly challenges that of the steam engine, a condition which is rapidly becoming, if it has not already become, true of the larger types which we are considering. Nevertheless, the number of parts and variety of their movements is vastly greater in this engine than in the turbine and the cost of supervision and operation is correspondingly greater; but leaving this question for a few minutes let us turn to that of capital charges.

These are made up of straight interest and an additional percentage on the investment which is set aside and saved at compound interest, so that at the end of the reasonable life of the plant we may have a sum in the bank equal to the original investment with which we can either pay off the investor or buy a new plant. Any operation which figures its costs on any other basis will probably go broke and certainly ought to. Five per cent at compound interest will equal the principal in about fourteen years, which is about all the life we have a right to expect from a power plant, for if it is not worn out in that time it has most likely been designed off the map. In other words, later improvements will have then made it commercially undesirable to operate any longer, even though it be not nearly worn out.

This 5 per cent added to the 7 per cent interest rate, which must be figured on industrial plants, gives us 12 per cent capital charges over and above all operating costs of every kind. This is a minimum figure for plants of this kind. Make no mistake; these are not bookkeeping figures, and the shores of commercial history are covered with the wrecks of plants which failed to provide for these charges. No sensible business man will put money into a property which cannot figure on this basis and still show a profit.

We see, then, that the annual cost of power is made up of fuel, labor, and one-eighth of the cost of the plant. Let me illustrate this to you. I know of a plant where a furnace is blown with two gas-blowing engines which cost about \$100,000 apiece, and which with foundation, house, crane and gas-cleaning apparatus and connections erected complete did not cost less than \$275,000. They develop together about 2500 hp., or a cost of \$110 per horsepower installed. Coal of 14,000 B.t.u. in this region costs about \$1 at the plant.

Steam engines of the best type, with their boilers and all accessories complete could have been installed for \$55 per horsepower. These engines would have been required certainly not to exceed 18,000 B.t.u. per horsepower-hour delivered to the boiler, while the gas engine may get along on 12,000. Counting 8780 hours per year, the loss of thermal units per year is $6000 \times$

8780 = 52,600,000 B.t.u. That is a large number of heat units. But how much money does it represent? One ton of coal costs fired say \$1.15 and contains $2240 \times 14,000 = 31,000,000$ B.t.u. In other words, it would require $1 \frac{2}{3}$ tons of coal per horsepower a year to make up the steam plant's deficiencies, or say, \$2 worth.

The difference in fixed charges, on the other hand, is 12 per cent of $(110-55) = \$6.60$ or a net loss of \$4.60 per horsepower year by the use of the gas engine with 100 per cent use factor. On the other hand, gas blowing engines are now being built which can be installed for \$75 per horsepower, and if these were used in a region where coal cost \$2.50 per ton, the cost of make-up coal would be \$4.20 and the fixed charges on increased investment be $0.12 \times (75-55) = \$2.40$, a difference of \$1.80 in favor of the gas engine under these conditions. This is a little less than 10 per cent on the additional capital required for the gas engine and might be considered a paying though by no means a startling investment, because owing to the uncertainties of industrial earnings, investors are not commonly interested in them unless they can see a manufacturing profit of about 15 per cent; and it is obvious that any additional expenditure required should show this amount or over to be justified. In this case the amount is 7 per cent interest plus 9 per cent net saving or 16 per cent in all. It is right in this range of conditions that it begins to be good business to install gas-blowing engines, though some authorities would insist that at least 2 to 3 per cent larger capital charges should be assessed against the gas engine on account of its high rate of physical depreciation, and all the evidence I have indicates that this is correct.

Turning now to the generation of electric power, we find the conditions different again because we have on the steam side the turbine with the direct rotary movement and its great capacity, while on the other we have the relatively slow speed of the gas engine and the consequent high cost of its generator with probably greater friction and less efficiency than when connected to a blower.

For these conditions we may take costs of \$70 and \$50 respectively per kilowatt installed and heat consumptions respectively of $12,500 \div 94 = 13,300$ B.t.u. per horsepower for the gas engine, and $12,500 \times 0.96$

$\frac{12,500 \times 0.96}{0.77} = 15,600$ per horsepower for the turbine, or 17,700 and 21,750 per kilowatt-hour respectively.

The use factor is much lower in electric service than it is in blowing-engine service. If we take 60 per cent we shall be liberal. This means that on account of peak loads for which it is necessary to provide, the plant in the course of a year will only put out 60 per cent of its maximum rated power. This factor varies very much in different works, but is higher in all of them than in public service plants.

The heat consumptions are about what may be expected under such conditions of loading and are not altered by this condition and neither are the costs, but the relative relations of these two are profoundly altered.

The excess thermal units per kilowatt year at full-rated capacity for the turbine above those for the gas engine are $8780 \times (21,750 - 17,300) = 39,100,000$, and the coal to supply this at 31,000,000 B.t.u. per ton is 1.26 tons at \$2.50 per ton. This is worth \$3.15, but the use factor is only 60 per cent, so that only 60 per cent as much coal is required for make-up, and its value drops to \$1.90 while the fixed charges are $12 (70 - 50) = \$2.40$.

In other words, in such a case the saving in coal

would not pay all the capital charges in the increased investment which therefore would be a bad one. Moreover, while the cost of labor and supervision for gas blowers may be no greater than that for steam engines and boilers together, undoubtedly their cost for gas-driven generators is greater than it is for steam turbines and boilers, and this increased cost would further throw the scale against the gas engine. But as the cost of coal rises, conditions are reached under which the gas engine pays, while as its first cost falls the fixed charges fall also, and tend to make its employment sound from the business point of view.

It will now be seen, I think why John Doe in Tyrone, where coal is cheap, may be a fool to do what had paid Richard Roe well in Boston where coal is dear, and the engine that is the most economical of coal may be a lot the most wasteful of dollars.

There are certain electrical considerations involved in the very variable load of the steel mill that give the turbo-generator advantages not covered by this discussion, but of great importance and very tangible value in operation. These considerations probably make it desirable, if not essential, that part of the electric power at least be developed by turbo-generators even if the main supply be from gas engines.

One fact cannot be too strongly emphasized. This is that the decision that a certain type of mover is the best for blowing purposes by no means involves the conclusion that the same type is best for electric power developments. One principal reason for this is that the blowing power for each furnace necessarily being isolated, the largest blowing unit is limited at the most to about 2500 hp., that being the approximate power required to blow a 500-ton furnace, and for safety it is desirable to have this divided into two units, whereas electric units may be built as large as 35,000 hp., and these larger ones are lower in both first and operating cost than the smaller ones, while they are entirely free from the electrical troubles due to variation in angular velocity to which the gas engine is liable.

The greater reliability and smaller upkeep of the turbine give it an advantage over the gas engine not fully covered even by the necessary allowance in operating costs, because certainty of operation has a cash value from the point of view of the whole works which power cost does not touch.

For the generation of electric power the reciprocating steam engine on account of high first cost of generator and higher operating cost is not to be compared with the turbine in powers larger than 2000 hp.

One factor of great importance in decision as between gas and steam engines is that of the efficiency with which the gas is burned under the boilers, while the efficiency of combustion in stoves has an enormous effect on the quantity of gas used for that purpose or left for outside utilization. For many years gas was burnt most wastefully as no attention was paid to the subject, but in recent years it has been carefully investigated and vastly improved. Diehl, Eldridge, Bradford, Boynton, Green, Huessner and a host of others have investigated existing burners and built better ones until the efficiency of boilers using furnace gas has gone from about 50 per cent to over 70 per cent in many cases and nearly 80 per cent in some. With this has gone an increase in the steam produced per boiler which, of course, cuts down the capital cost as well as the fuel cost.

The result is that while the steam motor might have been at a hopeless disadvantage even in spite of its advantage in fixed and operating costs a few years ago, it might easily beat the gas engine on the same basis to-day. The general principles on which these improvements have been made are simple, being merely the

well-known principles of all good combustion, first, correct proportioning of gas and air on the injector principle so that a change in the rate of flow of one makes a corresponding change in the flow of the other; second, the thorough mixing of the air and gas before they reach the zone of combustion; third, the control of the draft at the outlet to the stack so as to maintain the rate of flow of the products of combustion at the best velocity without drawing in any excess air.

The establishment of these conditions may require that either the air or gas be put under light pressure by a fan to supply the velocity required for injector action and for proper mixing, also in some cases to give sufficient velocity without excessive stack draft. The expense of operating the fan is insignificant in comparison with the enormous saving made by the improvement in combustion when these principles are correctly applied.

Where a furnace is not operated in conjunction with steel works there may still be a market for the surplus gas. This may be developed in the form of a sale of electric power to the public service company, but the stringent requirements of continuity in that service have made many operators chary of contracting with them.

Where the gas cannot be sold in this way it may be sold for heating purposes, but the field is rather limited, because the small heat value of the gas makes its transportation expensive and unfits it for any but relatively low temperature operations since the combustion temperature of furnace gas is not high.

In spite of these difficulties the enormous potential value of the gas justifies far greater efforts to conserve and sell its energy than have been made in the past.

In conclusion it is worth repeating that the possibility of disposing of this asset either as electric energy or heat is much greater in the vicinity of a city, and this is destined to induce the location of merchant furnace plants near thickly settled communities in the future to a greater extent than in the past.

Commercial Limitations to Fuel Economy

A few years ago the maximum degree of fuel economy was not only technically desirable, but was commercially necessary for survival, but this is no longer the case. There are conditions in which the commercial results are better with very moderate fuel economy than with the highest. The two developments which have brought about this change are the introduction of the by-product oven and the economic development of power generation with furnace gas, especially the gas engine.

One of the fundamental conditions for the occurrence of this paradox is that there shall be a market for all the surplus power developed. Let us assume then, the most common case of a combined plant of blast furnaces and steel works in which the latter furnish a market for all the power which can be supplied by the former. Assuming a high cost of coal brings out the facts more clearly, let us then assume that coking coal costs \$2.10 delivered at the works. If this were coked in old-fashioned ovens the yield would be about 60 per cent and the coking cost would be about 60 cents per ton of coke; coke, therefore, would cost $2.10 \div 0.6 + 0.60 = \$4.10$ per ton, and this cost would represent less than 60 per cent of the heat value of the fuel. The same coke in modern by-product ovens would yield 70 per cent of good screened coke, and the coking cost would be about 75 cents per ton of coke, so that coke would

cost $\frac{2.10}{0.7} + 0.75 = \3.75 per ton. There are, however,

some important deductions from this figure. The gas can be sold to the steel works for heating furnaces, the tar and ammonia are recovered (the latter in the form of ammonium sulphate) and sold; while under present and probably future conditions the benzol can be recovered at a handsome profit also.

The value of these by-products varies with the location, but is seldom or never less than \$1 per ton of coal. In a region of high-priced fuel such as we have assumed, \$1.50 per ton of coke would be a safe estimate. This would reduce the cost of coke to \$2.25 per ton; in other words under such circumstances a ton of coke would cost little more than a ton of coal in spite of the loss of weight and the cost of the operation.

Cases exist in which the coke actually costs less per ton than the coal from which it is made, the value of the by-products making up all the losses and paying all the costs of the operation.

Turning now to the utilization of the coke, all the heat energy it contains, not consumed in the necessary operations of the blast furnace, is returned in the form of gas, and because this gas contains only a small percentage of its heat in sensible form the efficiency of conversion is very high. Ordinarily the sensible heat of the gas is less than 5 per cent of the heat of the coke, and we may say that the efficiency of the blast furnace in its double function of iron maker and gas producer is 95 per cent; or, on a more conservative basis, we can say that since only about 10 per cent of the total energy of the gas is sensible heat the efficiency of the blast furnace as a gas producer alone is 90 per cent or better, whereas that of the standard gas producer, measured on the basis of the energy in the cold gas divided by that in the coal, is only about 65 to 75 per cent.

We have already seen that the gas engine has a considerable advantage over the steam turbine in heat consumption, if we start with gaseous fuel; and the tremendous efficiency of the blast furnace as a gas producer enables us to utilize this advantage of the gas engine in regions of high-priced fuel where the saving will pay the fixed charges on the greater investment.

In other words, admitting as we must, that there are considerable technical advantages in the use of gaseous fuel for power development, it is obvious that these may be commercially realized much more easily when the gasification is done as it is in the blast furnace with a thermal efficiency of 90 per cent and without labor and capital charges than they can when the efficiency of gasification is 65 per cent and the cost 50 cents per ton of fuel, as in the gas producer.

If we convert as much of the coal into coke as the furnace can conveniently take and utilize the resulting gas to the full, the total fuel and power bill measured in dollars and including fixed charges of a combined plant under such conditions is smaller than if we work with the highest fuel economy in the furnace and supplement the power required by the use of coal either in gas producers or under boilers. Of course, the ability of the furnace to consume coke is limited and its output of iron increases, other things being equal, as the coke per ton of iron decreases, and if we tried to run the coke per ton of iron unreasonably high the iron output would fall and profits be seriously reduced.

It is worthy of note that the highest fuel economy can only be obtained with very high blast heats, which means a decided increase in the gas required for blast heating. After we have reached the limit of commercial coke economy every such increase in gas consumption for this purpose represents an absolute loss.

It is worthy of note also that these conditions bring about a justification for high solution loss, since we

have seen that solution cools down the top gases and reduces the loss due to sensible heat, and it reduces the quantity of blast required per pound of coke and thereby reduces the pressure required to blow the furnace so that there is a material saving in the power consumed per ton of iron, for blowing.

It cannot, however, be too strongly emphasized that where these conditions do not prevail, where the cost per thermal unit of coke is materially higher than that of coal, or where there is no market for all the power which can be produced, or the cost of coal is too low to justify the completest utilization of gas, fuel economy is just as important as it ever was. These are the conditions which generally prevail at merchant furnaces, especially those which buy their coke.

The Dry Blast

The fact that the large steel works of the country have generally not installed dry blast plants has led some of those interested in such matters to believe that there was no ground for the claims of fuel economy made for dry blast, but nothing could be further from the facts. The real case of the dry blast depends upon the considerations set forth in the last section. Where it does not pay commercially to run the furnace for maximum economy for reasons there set forth, obviously it may not pay to install dry blast to obtain fuel economy; but, on the other hand, in the many cases where every pound of coke burnt unnecessarily means so much money lost, especially where the climate is damp, the dry blast is commonly a highly profitable investment.

There are special conditions in which furnaces have available more blast heat than they need or can use, and in such cases the only gain from the dry blast is the increased uniformity of operation, and it is a matter for careful consideration whether dry blast will pay or not.

The most marked instance of this kind is the charcoal furnace with high-blast heat and on rich ores. In the case cited in the article on thermal principles the "hooding in" of the air cylinder of the blowing engine resulted in lowering the moisture very decidedly, but did not have any effect on the fuel economy, and the application of the dry blast to another charcoal furnace running under similar conditions did not have any adequate result on the fuel consumption.

On the other hand, practically all the tests made at merchant coke furnaces equipped with dry-blast plants have shown a saving in coke and an increase in product of a value to pay for the dry-blast plant in two or three years.

It is very unfortunate that dry-blast plants have hitherto not been built in the South where the humidity is high, with the exception of one plant which has not been operated long enough at this writing to demonstrate the advantages of the process in that region. But I have taken records for years at a time which showed a fuel consumption lower by 20 per cent in the dry than in the humid season, and this represented only a part of the total saving. For during the humid season the margin of hearth heat was reduced to the point where slight variations were liable to throw the furnace completely off its balance, and the hearth heat per pound of fuel being very small the furnace was not sensitive to changes of burden and, therefore, very difficult to keep in regular operation. Serious troubles such as breakouts were very much more common, and as a result the operating costs were very much higher during the humid season.

This was so serious that as long ago as 1896 I endeavored to induce the owners to install refrigerating

apparatus to dry the blast, and was able to show to my own complete satisfaction that it would have been a vastly profitable investment, but no attention was paid to the suggestion by the owners. This was eight years before the publication of Mr. Gayley's results, and none of us had the slightest idea that anyone else was working on the plan, though I subsequently found that Mr. Gayley had taken out patents on the process two years before I started on it.

On another occasion in the Birmingham district, furnaces running on foundry iron fell off in the grades produced in the early spring, a time when ordinarily the humidity is quite low, but the season had been a very warm one, and when I consulted the humidity records I was astonished to find that the humidity had risen enough to account for the increased coke required to restore the grades, a very considerable amount.

Two points in connection with dry blast are of much importance; first, it is the absolute and not the relative humidity on which the possible saving depends; second, the amount of saving possible is susceptible of reasonably accurate calculations. The relative humidity means the percentage of the moisture which the air actually contains measured in terms of the amount it would contain if saturated at *that temperature*. But the amount of moisture which the air contains at saturation increases with great rapidity as the temperature rises.

Referring to the chart given in the chapter on dry blast, it will be seen that at 0 deg. Fahr. this amount is 0.05 lb. per thousand cubic feet; at 32 deg. Fahr., 0.27 lb.; at 60 deg. Fahr., 0.8 lb.; at 70 deg. Fahr., 1.13 lb., and at 80 deg. Fahr., 1.6 lb; therefore the humidity in percentage means nothing whatever unless we know the temperature. On a foggy day with the temperature at 32 the humidity seems excessive, and in fact fog means that the air is super-saturated; while on a summer day with the thermometer at 80 and the humidity 50 per cent of saturation the air would seem excessively dry, but in the latter case it would contain nearly three times as much moisture per cubic foot as in the former.

We can determine the fuel saving possible in any given case where the humidity during each month of the year is known by the use of the charts of hearth heat in the article on thermal principles. We first determine the average absolute moisture in the air for each month, then decide on the point to which it will pay to dry it, and deduct the coke consumption for the second case from that of the first. To do this, of course, requires a knowledge of the blast and critical temperatures, at least approximately, for the given conditions.

The humidity in the air for each month can be obtained from the nearest Weather Bureau Station. It is desirable to obtain it for at least two years and average the results. This information (furnished freely by the Weather Bureau officials) forms an excellent basis on which to start, but it is necessary to have in mind that these stations are generally located at the highest point available and that the humidity at the ground level may be locally very much higher, especially on the banks of large bodies of water, rivers, lakes or cooling ponds, where furnaces are usually located. Cooling ponds and rivers in industrial districts in particular are likely to throw off large volumes of moisture, even beyond the saturation point of the surrounding air. Within a few hundred yards this is all absorbed and averaged up in the vast volumes of surrounding dry air, so the results at the Weather Station may not be much affected, but the local increase in humidity in the vicinity of the plant may be commercially of great importance.

For the reason it is well to determine definitely the humidity in the vicinity of the blowing engine intake over a period of several weeks at least, and compare the results with those of the Weather Bureau. A few weeks will generally give a fair idea of the local increase, but of course it is desirable to have it for a year if possible.

Knowing the coke saving per ton, and the cost of coke, and the tonnage made per day, we can easily figure the saving from this source. A comparison of this with the cost of a dry-blast plant will generally show that at merchant furnaces without a market for their surplus power the saving will pay for the installation in a short time.

In addition to the saving in fuel and the corresponding increase in tonnage which results, there is a saving in smoothing out the irregularities which result from variations in humidity, whose effect as explained above may be very serious from a financial point of view. This saving, due to the uniformity, has sometimes been claimed to be greater than that due to the drying itself, and while I cannot subscribe to that view there is no doubt that it is extremely important, especially in the case of merchant furnaces where the control of grades is so much more important commercially than at steel works' furnaces.

We can then summarize the status of the dry blast as follows: If first there is a market for heat in the form of combustible gas at a price per thermal unit equal to or better than that for coal, and second, if the money cost of a thermal unit in the form of coke is but little greater than that in the form of coal, the fuel economy in the furnace beyond a point soon reached has a negative value and a dry-blast plant to promote fuel economy, accordingly cannot ordinarily pay. Or where the furnace has available from hot blast alone more hearth heat than it needs for its conditions (practically, this means only charcoal practice on rich ores), the advantage of the dry blast becomes a very secondary one. But where coke consumption reduced means money saved, and where strict grade control means more money earned, then the dry-blast plant is usually a highly profitable investment.

In conclusion it may be pointed out that the introduction of the by-product oven by reducing the value of coke in comparison to that of the coal from which it is made, and the gas engine by giving to the surplus gas from the furnace a commercial value per thermal unit, in some cases equal to that of the coke itself, have been the principal causes of the non-introduction of dry-blast plants at steel works' furnaces.

Annealing of Aluminium*

BY RICHARD SELIGMAN AND PERCY WILLIAMS

It has been shown by various workers that hard worked amorphous metals undergo changes at comparatively low temperatures. Thus Beilby¹ points out that a rapid release of strain occurs in hard worked metals at 100 deg. C., while Lowry and Parker², when studying the specific gravity of aluminium filings, observed a decrease in the gravity when the filings were heated to 100 deg. C. Recently Brislee has observed changes in various physical properties of aluminium at 100 deg. C.³

During the course of a long series of experiments upon the solubility of aluminium in nitric acid it has been noticed incidentally that by heating hard worked metal to 125 deg. C. a definite change in the rate of dis-

solution is brought about. Hard worked aluminium is more readily soluble in nitric acid than the same metal when annealed. Thus, for instance, a sample of hard worked aluminium which lost 56 mgr. per 100 sq. cm. per twenty-four hours when immersed in 1.42 nitric only lost 39 mgr. when similarly exposed after being annealed at 500 deg. C., a decrease of 30 per cent.

When the hard worked sheet was heated for 10 hours at 125 deg. C., it was found that the rate of dissolution had fallen from 56 to 53 mgr. per 100 sq. cm. per twenty-four hours. This is equivalent to a decrease of 5.3 per cent. Strips heated at 100 deg. C. instead of 125 deg. C. gave similar results, although the reduction of the rate of dissolution was somewhat smaller, namely, about 3 per cent.

It was anticipated that if the heating were prolonged the decrease in the rate of dissolution might be augmented. This was not found to be the case, but, on the contrary, as the heating at 125 deg. C. was prolonged the fall in the rate of dissolution diminished, until samples heated for 80 hours at 125 deg. C. showed the same or even a slightly higher rate of dissolution than samples which had not been heated at all. This reversal was not noted in the case of samples heated at 100 deg. C., but was observed in a large number of samples heated at 125 deg. C.

The facts recited do not appear to tally completely with the observations of other workers. A release of strain as indicated by Beilby should be accompanied by a reduction in the rate of dissolution, but such a release of strain would not account for the subsequent increase. An allotropic change such as Cohen and others describe for many metals would fit in with the changes in the rate of dissolution observed but for the fact that the reversal took place at the temperature which had brought about the first change. Finally, Brislee appears to differ from all others in that the change he observed went much farther, and seemed to indicate progressive crystallization even at 100 deg. C.

A further anomaly has been observed in dealing with metal annealed at higher temperatures. It has been noted on many occasions that aluminium which has been freshly annealed has a lower rate of dissolution in nitric acid than a sample of the same metal which has been allowed to stand for several days after annealing. Thus, for instance, a sample of metal which, when freshly annealed at 440 deg. C., dissolved in nitric acid at the rate of 31 mgr. per 100 sq. cm. per twenty-four hours, dissolved at the rate of 36 mgr. thirteen days after annealing. On re-annealing at 440 deg. C., the rate of dissolution fell again to 32 mgr. per 100 sq. cm. per twenty-four hours.

Attention is drawn to these facts in the hope that it may be possible for some of those who are interested in these changes to investigate them more closely, as the present authors are not likely to have an opportunity of pursuing the matter farther.

Glass-Enameled Steel Apparatus.—The Pfaunder Co., Rochester, N. Y., has issued chemical trades bulletin C-3, describing Pfaunder glass-enameled steel apparatus for chemical industries.

The General Electric Co., Schenectady, N. Y., is planning an interesting exhibit at the Foundry and Machine Exhibition to be held at The Wigmore Coliseum, Cleveland, Ohio, during the week of September 11, in conjunction with the Convention of the American Institute of Metals and the American Foundrymen's Association. The exhibit will include an interesting line of control devices, switchboards, panels, and other material, with a 300-ampere portable arc-welding outfit.

*A paper presented before the Electrolytic Society in London on May 9, 1914.

¹Beilby, *Trans. Faraday Soc.*, X, p. 212 (1915).

²Lowry and Parker, *F. C. S.*, 1907, p. 100; 1908.

³Private communication.

The Time Factor in the Formation of Aromatic Hydrocarbons from a Paraffin Base Oil

BY GUSTAV EGLOFF AND THOMAS J. TWOMEY

The time factor in the thermal decomposition of hydrocarbon oils for the formation of oil gas, gasoline or aromatic compounds of the benzene series is quite as important as the other four variables of chemical reactions: temperature, pressure, concentration and catalysis. In this communication the time factor has been studied in the formation of aromatic hydrocarbons from a paraffin base oil at constant temperature and pressure.

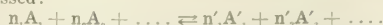
The time factor has been noted by a number of investigators in the thermolizing of a gas oil, for the production of oil gas. Hempel¹ has followed the effect of time upon the composition of oil gas from the cracking of gas oils at temperatures between 700 deg. and 900 deg. C. Tocher² and Jones³ have reported results as to the effect of time upon the products from the heat treatment of oils.

The most systematic piece of work upon the time factor in relationship to the decomposition of a kerosene oil and the resulting products in the gas formed has been made by Whitaker and Alexander.⁴ They have shown that the control of the gaseous products formed from the decomposition of a hydrocarbon oil is a function of the time factor when cracking takes place at constant temperature and pressure.

Rittman⁵ and co-workers in thermolizing an Oklahoma crude petroleum oil for the production of benzene and toluene at constant temperature, pressure and rates of oil flow from 11 to 27 gal. per hour, found that as the oil rate increased decrease of decomposition of the starting oil occurred. No marked percentage change in the starting oil took place as the rate was increased. A change of only 8 per cent is recorded. This was explained upon the basis of insufficient condensation of the system. Nevertheless, the data as expressed in Table 2 are good qualitative information as to the effect of time upon aromatic formation from a petroleum crude oil. Table 1 gives the analysis of the starting oil, using a Hempel distillation set⁶

statement the total progress of a chemical reaction which occurs in a homogeneous system is determined by the difference of the two reaction velocities of the system going in opposite directions as expressed by a reaction equation. From this the velocity of a reaction at every instant of time, *i. e.* the amount of material changed per unit time, may be expressed in the following manner:

The representation of any chemical equation may be expressed:



This reciprocal reaction, each of which has a separate reaction velocity and, expressed symbolically, gives:

$$v = k(A_1)^{n_1}(A_2)^{n_2} \dots \quad v' = k'(A'_1)^{n'_1}(A'_2)^{n'_2} \dots$$

The change per increment of time $\frac{dx}{dt}$ is shown as follows:

$$\frac{dx}{dt} = v - v' = k(A_1)^{n_1}(A_2)^{n_2} \dots - k'(A'_1)^{n'_1}(A'_2)^{n'_2} \dots$$

k and k' are speed constants of the two opposing reactions, $A_1, A_2, \dots$ are the concentrations of the reacting substances, $n_1, n_2, \dots$ are the coefficients of the reacting substances derived from a balanced reaction equation.

Though the above relationships have been studied for reactions of uni, di, tri and higher molecular reactions in which the time factor has been followed, no such relatively simple conditions in a thermolized oil sub-

TABLE 3
One Gallon of Oil Vaporized in the Cracking Area in Minutes and Seconds

Rate, Gals. Per Hour	Time, Minutes and Seconds
12	5.00
16	3.45
23	2.36
30	2.00
36	1.39

jected to varying rates of oil flow exists. The cracked oil is an enormously complex mixture of aliphatic and aromatic hydrocarbons and at present the quantitative application of the mass action law is of small value in a study of the temperature, pressure, and time factor involved in the cracking of hydrocarbon oils for aromatic formation.

In this study the effect of rate of oil flow upon the products produced from the reaction at constant temperature and pressure has been made. When the oil is passed into the cracking area, at rates from 12 to 36 gal. per hour, the rates may be expressed in the time factor units as given in Table 3.

The experimental values from Table 5, of 12 gal. per hour, which in point of time gives 5 minutes per gallon of oil in the vapor state, gave maximum decomposition of the starting oil. As the time decreases in which 1 gal. of vaporized oil is in the heated area of the tube, the amount of initial oil decreases. Now in chemical reactions, the time factor which is representative of the interval of time during which a reaction progresses, as illustrated by the above equations, is theoretically deducible from reaction velocity considerations. As shown from the data, increase of rate of oil flow decreases the time in which the oil vapors are in the reaction zone of the heated tube.

Analysis of the Oil Used

The paraffin base oil utilized in these experiments was one which is commonly called a distillate or gas oil. It was derived from a paraffin base Pennsylvania crude petroleum and analyzed as follows: It boiled between the ranges of 200 deg. and 350 deg. C. to the extent of 95.3 per cent. Distillation of the oil was de-

TABLE 1

Spec. Grav. 0.817/15.5°C.

Distillation Analysis of Oklahoma Crude Petroleum Used

Temp., Deg. C.	Per Cent Volume	Sp. Gr.
0 to 75	1.5	0.720
75 to 100	3.5	0.722
100 to 125	7.0	0.735
125 to 150	11.0	0.752
150 to 200	14.0	0.782
200 to 250		0.786
250 to 300	17.5	0.836

TABLE 2

The Formation of Benzene and Toluene from the Cracking of an Oklahoma Crude Petroleum at a Temperature of 700 Deg. C. and 250 Lbs. Pressure at Rates from Eleven to Twenty-seven Gallons Per Hour

Rate, Gals. Per Hr.	Per Cent Recov. Oil	Per Cent Benzene in Recov. Oil	Per Cent Toluene in Recov. Oil	Per Cent Benzene in Toluene in Orig. Oil	Per Cent Toluene in Orig. Oil
11	21	18.7	13.8	3.9	2.9
14	25	23.2	12.0	5.8	3.0
18	22	20.0	12.7	4.4	2.8
23	25	10.8	10.0	2.7	2.5
27	29			1.5	2.2

The Time Factor Involved in the Thermal and Pressure Decomposition of a Paraffin Base Oil

The fundamental law of chemical kinetics is expressed in the law of mass action. According to this

¹Hempel, Jour. Gasbel, 53, 77, 101, 137, 155, 1910.

²Tocher, Jour. Soc. Chem. Ind. 13, 231, 1894.

³Jones, Amer. Gaslight Jour. 99, 273, 1913.

⁴Whitaker and Alexander, Jour. Ind. and Eng. Chem. 7, 484, 1913.

⁵U. S. Bureau of Mines Bull. 114.

⁶Rittman, Twomey and Egloff, Met. and Chem. Eng. 13, 682, 1915.

terminated by means of a standard 100 c.c. Engler flask. The specific gravity was taken by means of a Westphal balance at 15.5 deg. C. and gave a value of 0.827.

Temperature, Deg. C.	Per Cent by Volume	Specific Gravity
0 to 250	2.9	0.772
200 to 250	10.0	0.772
250 to 300	43.6	0.829
300 to 350	33.8	0.855
Residue	4.2	0.772
Loss	0.5	0.772

Twenty gallons of oil were used in each experiment.

Experimental Procedure

The paraffin base oil was pumped through a carefully calibrated oil meter at rates from 12 to 36 gal. per hour, at constant temperature of 700 deg. C. and pressure of 150 lb. per sq. in.

The system which was a closed one consisted es-

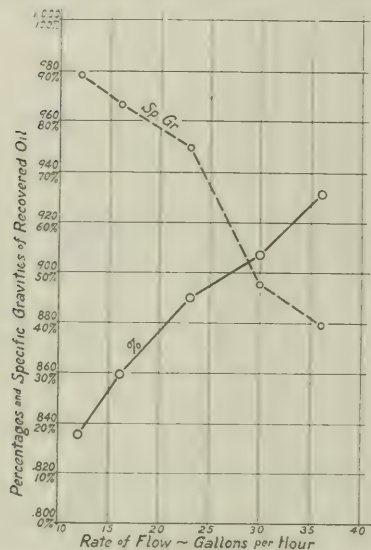


FIG. 1—THE EFFECT OF RATE OF OIL FLOW ON THE PER CENT OF RECOVERED OIL—AND THE SPECIFIC GRAVITY OF THE RECOVERED OIL

sentially of a lap welded steel tube of $\frac{5}{8}$ in. wall, 11½ ft. in length and 8 in. in diameter. The steel tube was connected with a tar body and stirring rod device for the removal of any carbon formed upon the inner wall of the tube. From the fan box above the tar body a 3-in. header ran to the condensing system which was adequate for these experiments. A triplex pump with an accumulator for the pumping of the oil against the 150-lb. of gas pressure of the system was efficient. A gas-heated muffle-type furnace was used.

Before each run the pressure was built up by means of a compressor to 150 lb. with natural gas. The temperature control was determined by means of a base metal thermo-couple which was accurate to 5 deg. C. plus or minus.

The rate of oil flow into the cracking area under constant temperature and pressure was: 12, 16, 23, 30 and 36 gal. per hour. Before each run the oil meter was carefully calibrated, due to difficulty in finding an oil meter which would remain accurate for any length of time.

By careful regulation of the pressure in the cracking system, the rate of oil flow was maintained constant by the pump. The excess pressure built up by the cracking of the oil was released by means of a pressure valve

and was never allowed to exceed or fall below 150 lb. pressure; for change in pressure exerts a marked influence upon the decomposition of the starting oil. The temperature, pressure and rate of oil flow during each experiment were held constant.

Experimental Data

The data as experimentally determined are brought out by means of the following tables and figures:

Table 5 and Fig. 1 give the effect of rate of oil flow on the per cent. of recovered oil and the specific gravity of the recovered oil.

Table 6 and Fig. 2 give the effect of rate of oil flow on the formation of benzene, toluene and xylene in the recovered oil.

Table 7 and Fig. 3 give the effect of rate of oil flow on the formation of benzene, toluene and xylene on the basis of oil used.

Table 8 and Fig. 4 give the effect of rate of oil flow on the distillate to 170 deg. C. and the specific gravity of the distillate.

Table 9 and Fig. 5 give the effect of rate of oil flow on the specific gravity of the benzene cut 0 deg. to 95 deg. C.; on the specific gravity of the toluene cut 95 deg. to 120 deg. C.; and the xylene cut 120 deg. to 150 deg. C.

Table 10 and Fig. 6 give the effect of rate of oil flow

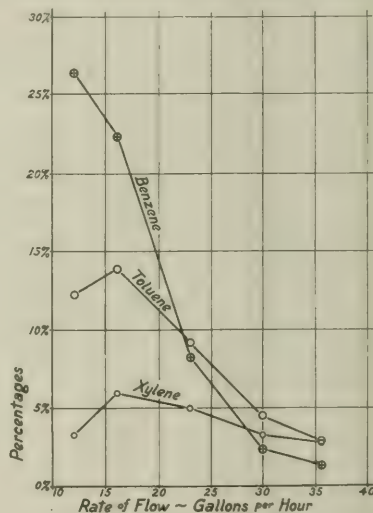


FIG. 2—THE EFFECT OF RATE OF OIL FLOW ON THE FORMATION OF BENZENE, TOLUENE AND XYLENE IN THE RECOVERED OIL

on the distillation cuts of the oil residue above 170 deg. C. and the specific gravity of the cuts.

The Effect of Rate of Oil Flow on the Per Cent of Recovered Oil and the Specific Gravity of the Recovered Oil		
Rate Gallons Per Hour	Per Cent of Recovered Oil	Specific Gravity 15.5° C.
12	17.5	0.978
16	29.7	0.966
23	44.8	0.949
30	52.3	0.895
36	63.5	0.879

The Effect of Rate of Oil Flow on the Formation of Benzene, Toluene and Xylene in the Recovered Oil			
Rate Gallons Per Hour	Per Cent Benzene	Per Cent Toluene	Per Cent Xylene
12	26.3	12.3	3.5
16	22.3	13.8	3.5
23	8.3	9.2	4.9
30	2.3	4.5	3.2
36	1.3	2.8	2.7

TABLE 7

The Effect of Rate of Oil Flow on the Formation of Benzene, Toluene and Xylene, on the Basis of the Oil Used

Rate Gallons Per Hour	Benzene Per Cent	Toluene Per Cent	Xylene Per Cent
12	4.6	2.2	0.6
16	6.6	4.1	1.8
23	3.7	1.1	2.1
30	1.2	2.4	1.7
36	0.8	1.8	1.7

TABLE 8

The Effect of Rate of Oil Flow on the Distillate to 170° C. and the Specific Gravity of the Distillate

Rate Gallons Per Hour	Per Cent to 170° C.	Specific Gravity 15.5° F.
12	44.3	0.875
16	44.7	0.868
23	37.3	0.857
30	30.9	0.792
36	25.7	0.781

TABLE 9

The Effect of Rate of Oil Flow on the Specific Gravity of the Benzene, Toluene and Xylene Cuts at 15.5° C./15.5° C.

Rate Gallons Per Hour	Benzene Cut 0° to 95° C.	Toluene Cut 95° to 120° C.	Xylene Cut 120° to 150° C.
12	0.876	0.872	0.871
16	0.868	0.867	0.869
23	0.814	0.818	0.822
30	0.756	0.815	0.823
36	0.744	0.800	0.814

TABLE 10

The Effect of Rate of Oil Flow on the Distillation Cuts of the Oil Above 170° C. and the Specific Gravity of the Cuts

Rate, Gallons Per Hr.	170° to 230° C.		230° to 270° C.		270° to Tar		Tar
	Per Cent	Sp.Gr.	Per Cent	Sp.Gr.	Per Cent	Sp.Gr.	Per Cent
12	18.0	solid	28.6	solid	8.5	solid	44.6
16	13.0	"	29.4	"	16.0	"	41.6
23	12.1	0.923	35.7	0.954	12.7	0.995	39.6
30	15.7	0.891	27.6	0.905	24.2	0.930	32.8
36	21.4	0.884	30.0	0.902	21.0	0.911	27.6

Discussion of Experimental Data

A.—THE EFFECT OF RATE OF OIL FLOW ON THE PER CENT OF RECOVERED OIL AND THE SPECIFIC GRAVITY OF THE RECOVERED OIL

When a paraffin base oil is passed through a heated tube above the vaporization point of the hydrocarbons present, dependent upon the temperature of decomposition profound changes take place in the starting oil.

The oil recovered from the cracking is composed of aliphatic and aromatic hydrocarbons differing in their constitution as the temperature is increased.

Likewise the time factor or the rate of oil flow into the heated area of the tube brings about profound changes in the initial oil. By varying the time factor at constant temperature and pressure, the recovered oil differed in constitution from the starting oil and from each other widely.

From Fig. 1 it will be observed that the rate of oil flow has a marked effect upon the per cent of recovered oil obtained in each experiment.

A priori reasoning would indicate that the amount of decomposition of the oil should be directly proportional to the time factor or rate of oil flow. Quite different results were obtained experimentally.

The maximum decomposition took place between 12 and 16 gal. per hour, where for each gallon change in rate a difference of 3.05 per cent in the recovered oil resulted. From 16 to 23 gal. per hour a change of 2.16 per cent took place per gallon change in rate. The minimum of change took place between the rates 23 and 30 of 1.2 per cent. As the rate was increased from 30 to 36 the change per gallon of oil flow gave a 2.05 per cent difference in the recovered oil.

This indicates the close inter-relationship of the temperature and the time factor, for in a previous set of experiments where the temperature effect was studied, a critical temperature drop was noted quite similar in its characteristics, to the time factor.¹ The per cent of recovered oil increased as the rate of oil flow was in-

creased, while the per cent of recovered oil decreased with increase of temperature.

The specific gravity changed from 0.827 in the initial oil to 0.978 in the recovered oil as the rate of oil flow decreased from 36 to 12 gal. per hour.

With increase of temperature the specific gravity of the recovered oil increased also. This is in accord with the increase of specific gravity with increase of the time factor.

Due to the time factor at constant temperature of 700 deg. C. and 150 lb. pressure, the initial oil had changed from a paraffin oil to a mixture of paraffin, ethylene and perhaps acetylene series, and, aromatic hydrocarbons of the benzene and polycyclic series hydrocarbons.

From the high specific gravity of 0.978 in the 12 gal. per hour experiment, the lowest oil flow, the maximum aromatic formation is indicated.²

B.—THE EFFECT OF RATE OF OIL FLOW ON THE FORMATION OF BENZENE, TOLUENE AND XYLENE IN THE RECOVERED OIL

The effect of rate of oil flow upon the formation of benzene, toluene and xylene in the recovered oil is brought out by the data and Fig. 2. The interesting fact to be noted in the graph is that as the initial oil in the vapor state is allowed to remain in the heated zone the least in point of time or the maximum rate of 36 gal. per hour, the toluene and xylene form in greater quantity than benzene. This is equivalent to cracking at low temperature.³

As the time factor is increased benzene forms more rapidly than either toluene or xylene and at the maximum time of 5 minutes per gallon of vaporized oil in the heated zone, benzene formed is over twice the per cent of toluene and over seven times that of xylene.

The per cent of benzene decreased with increase of rate of oil flow from 12 to 16 gal. per hour, with a steep drop from 16 to 23, less so from 23 to 30 and only slightly from 30 to 36.

The changes in the formation of toluene are less marked and almost a constant increment of per cent of toluene is to be noted between the rates 16 to 30 gal. per hour. A slight falling off of toluene was found to occur at the rate of 12 gal. per hour. This would indicate that the toluene decomposed more rapidly to form benzene.⁴ The maximum formation of 13.8 per cent of toluene occurred at rate of oil flow of 16 gal. per hour.

The formation of xylene is much less than either toluene or benzene with one exception, at 36 gal. per hour. This rate gave the least decomposition of the starting oil. The maximum formation of 5.9 per cent of xylene occurred at 16 gal. per hour.

The conclusion drawn from these data is that as the initial oil vapors are allowed to remain in the cracking zone increasing lengths of time, the formation of xylene and toluene decrease and benzene increases to the maximum. The maximum of benzene was found to be 26.3 per cent at twelve gal. per hour, while the maximum for toluene was 13.8 and 5.9 per cent for xylene both at the rate of 16 gal. per hour. This brings out the control possible for the maximum formation of the hydrocarbon desired in the recovered oil by change of the time factor.

C. THE EFFECT OF RATE OF OIL FLOW ON THE FORMATION OF BENZENE, TOLUENE AND XYLENE ON THE BASIS OF OIL USED

Industrially the important fact is the production of maximum per cents of the most valuable aromatic hy-

¹Ibid.²Trittman and Egloff, Jour. Ind. Eng. Chem., 7, 481, 1915.³Egloff and Twomey, Jour. Phys. Chem., 20, 121, 1916.⁴Trittman, Brown, and Egloff, Jour. Ind. Eng. Chem., 7, 481, 1915.

drocarbons, benzene, toluene and xylene on the basis of oil used for their production.

In the graph resulting on the basis of oil used two factors are considered, the per cent of aromatic compound in the recovered oil and the per cent of the recovered oil.

In contradistinction to the curves for the aromatic compounds in the recovered oil the curves on the basis of oil used for benzene, toluene and xylene all show a

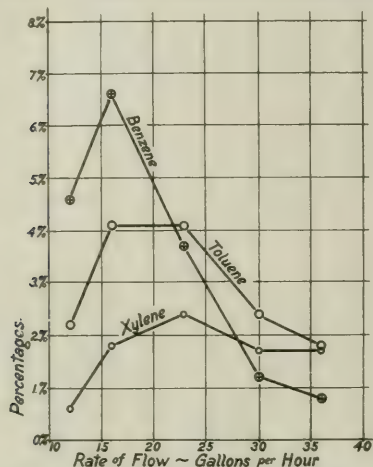


FIG. 3—THE EFFECT OF RATE OF OIL FLOW ON THE FORMATION OF BENZENE, TOLUENE AND XYLENE ON THE BASIS OF THE OIL USED

maximum but not under the same time factor or rate of oil flow.

The difference between the two sets of graphs lies in the fact that as the time factor increases, the percentage of aromatic formation increases while the per cent of recovered oil decreases.

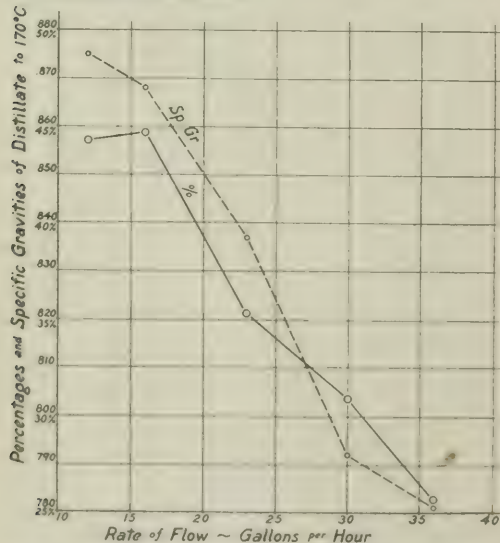


FIG. 4—THE EFFECT OF RATE OF OIL FLOW ON THE DISTILLATE TO 170° C. AND THE SPECIFIC GRAVITY OF THE DISTILLATE

Up to a certain point illustrated in the rate of oil flow for the different maxima shown, the per cent of the aromatic formation increased more rapidly than the per cent of the recovered oil decreased. With this factor influencing more than the latter, the per cent of the aromatic compounds on the basis of the oil used increased.

As the rate is further decreased the decomposition of the initial oil progresses more rapidly than the formation of the aromatics. A combination of these two factors brings about a maximum in the curve for aromatic formation.

In the recovered oil the formation of benzene, toluene, and xylene show different velocities of formation, with increase of the time factor. The maximum for benzene of 6.6 per cent on the basis of oil used was at the rate of 16 gal. per hour, or 3' 45" per gallon of oil vaporized in the heated zone. For toluene the maximum of 4.1 per cent was at the rate of oil flow of 16 and 23 gal. per hour, or expressed as actual time 3' 45" and 2' 36" per gal. of oil vaporized. Xylene gave a maximum of 2.4 per cent at 23 gal. per hour or 2' 36" per gal. of oil in the vapor state.

The graph is valuable in indicating the best conditions of oil rate at constant condition of temperature

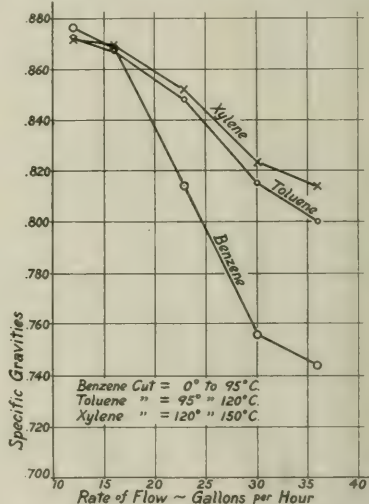


FIG. 5—THE EFFECT OF RATE OF OIL FLOW ON THE SPECIFIC GRAVITY OF THE BENZENE, TOLUENE AND XYLENE CUTS AT 15.5° C.—15.5° C.

700 deg. C. and 150 lb. pressure, for the formation of the aromatic hydrocarbons, benzene, toluene and xylene.

D.—THE EFFECT OF RATE OF OIL FLOW ON THE DISTILLATE TO 170 DEG. C. AND THE SPECIFIC GRAVITY OF THE DISTILLATE

The effect of rate of oil flow upon the distillate to 170 deg. C. is shown in Fig. 4 and indicates that as the time factor increases the percentage increases to a maximum and then decreases. The maximum formation of distillate to 170 deg. C. occurred at 16 gal. per hour and least at 36. The falling off at 12 gal. per hour is readily explainable upon the basis of an increased formation of polycyclic aromatic compounds which have higher boiling points than the derivatives of the benzene series.

The specific gravity of the distillate increases with increase of the time factor to the maximum of 0.875

which is clear indication that the distillate is composed practically of pure aromatic hydrocarbons.¹² At the lower specific gravities mixtures of paraffins, olefins and aromatic hydrocarbons are present, while increase of specific gravity indicates increase of aromatic compounds.

E.—THE EFFECT OF RATE OF OIL FLOW ON THE SPECIFIC GRAVITY OF THE BENZENE, TOLUENE AND XYLENE CUTS AT 15.5 DEG./15.5 DEG. C.

As the time factor increases from 2 to 5 minutes in which 1 gal. of oil in the vapor state is subjected to the heated zone of the tube, the purity of the cuts of benzene, toluene, and xylene increases until at the longest period of time, 12 gal. per hour of oil flow, almost pure benzene, toluene and xylene results from the cracking conditions of the experiment.

A specific gravity of 0.876 for benzene, 0.872 for toluene and 0.871 for the xylene cuts gives practically pure compounds which are readily separated by fractional distillation and clean up readily upon treatment with concentrated sulphuric acid.

In the other cuts with lower specific gravities a mixture of low boiling aliphatic hydrocarbons of the paraffin and olefin type are present, mixed with the aromatic hydrocarbons, benzene, toluene and xylene. The low boiling aliphatic hydrocarbons can readily be used for motor fuel either alone or blending with uncracked gasoline.

An idea of the purity of the distillation cuts from the specific gravity¹³ values, a comparison of the average gravity of the aliphatic hydrocarbons which have boiling points around those of benzene, toluene and xylene are given the following table:

	Average Spec. Grav. Aliphatic Compounds	Spec. Grav. Aromatics
Benzene cut 0° to 95° C.	0.72	0.881
Toluene cut 95° to 120° C.	0.73	0.871
Xylene cut 120° to 150° C.	0.76	0.869

The data indicate the changes produced upon increasing the time factor and that as the time of reaction is increased benzene, toluene and xylene relatively free from the aliphatic hydrocarbons of the paraffin and olefin type are formed.

F.—THE EFFECT OF RATE OF OIL FLOW UPON THE DISTILLATE FROM THE RECOVERED OIL ABOVE 170 DEG. C.

AS SHOWN BY DISTILLATION CUTS AND SPECIFIC GRAVITY

As the time factor increased the recovered oil was mainly aromatic in character.

At 12 and 16 gal. per hour the cuts from 170 deg. C. to tar gave naphthalene and anthracene, as shown by their appearance as solids in the cuts.

As the time of reaction decreased the polycyclic aromatic compounds decreased to zero.

It is of interest to note that as the time factor decreased the formation of tar or pitch decreased in the distillate above 170 deg. C. The mixture above 170 deg. C. is an extremely complex system and no regularity appears to be present judging from Fig. 6.

A minimum occurs in the cut from 170 deg. C. to 270 deg. C. Two maxima appear in the cut from 230 deg. C. to 270 deg. C., while the same appears to be true of the cut to tar.

The per cent of tar decreased with increase of rate of oil flow.

SUMMARY

1. The effect of the time factor or rate of oil flow has been studied at a constant temperature of 700 deg. C.

and 150 lb. pressure and rates of 12, 16, 23, 30 and 36 gal. per hour, for the formation of the aromatic hydrocarbons benzene, toluene and xylene from a paraffin base oil.

2. (a) As the time factor increased the per cent of recovered oil decreased from 65.5 to 17.5 per cent. The time factor is analogous to the effect of increasing the temperature of decomposition of the starting oil.

(b) Increase of the time factor increases the specific gravity of the recovered oil from 0.879 to 0.978/15.5 deg. C. The same phenomenon takes place when the temperature of thermolization of an oil is increased.

3. The maximum per cent of 26.3 of benzene in the recovered oil was found to be at the rate of 12 gal. per hour. The benzene formation increased with decrease

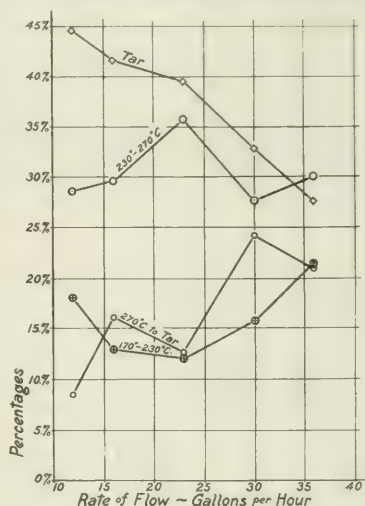


FIG. 6—THE EFFECT OF RATE OF OIL FLOW ON THE DISTILLATION CUTS 170°—230° C., 230°—270° C., 270° TO TAR, AND TAR

of rate of oil flow. The maximum percentages of 13.8 per cent toluene and 5.9 per cent of xylene were both obtained at the rate of 16 gal. per hour. Toluene and xylene showed an increase and then decrease, in their formation, while benzene increased continuously with increase of the time factor within the range of these experiments.

4. The maximum 6.6 per cent of benzene on the basis of oil used was obtained at 12 gal. per hour. The maximum for toluene of 4.1 was found at rates of oil flow 16 and 23 gal. per hour. Maximum formation of xylene of 2.4 per cent at 23 gal. per hour resulted at the temperature of the experiments 700 deg. C. and 150 lb. per square inch.

5. The per cent of distillate increased with increase of the time factor to a maximum of 44.7 per cent and then decreased. The specific gravity of the distillate to 170 deg. C. increased to 0.875 which indicated practically pure aromatic compounds of benzene, toluene and xylene present. The lower specific gravity of the distillate gave mixtures of aliphatic and aromatic hydrocarbons.

6. The specific gravity of the benzene, toluene and xylene cuts indicated the varying amounts of mixtures of paraffins, ethylene and aromatic series of hydrocarbons present. At the rate of 12 gal. per hour maximum purity of the cuts was obtained. Practically pure benzene, toluene and xylene were obtained from a paraffin base oil under these conditions of the experiment.

¹²Rittman, Twomey and Egloff, Met. and Chem. Eng. 13, 682, 1915.

¹³Rittman, Twomey and Egloff, Met. and Chem. Eng. 13, 682, 1916.

7. No regularity is apparent in the distillation cuts above 170 deg. C. with exception of the tar or pitch formation. Pitch formation decreased with increase of rate of oil flow.

8. Under the conditions of the experiments a maximum total of 12.5 gal. of the aromatic compounds benzene, toluene and xylene were obtained from 100 gal. of oil used, at rate of 16 gal. per hour, temperature of 700 deg. C. and 150 lb. pressure per square inch.

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Notes from the Palmer Physical Laboratory

Maximum Watt-Dissipation is Still Air from Nickel Wire and Other Data

BY E. S. NORTHRUP

In the tests to be described the objects held in view were: a—To determine the watts per cm² dissipated in still air from the surface of pure nickel wires with circular cross-section when raised by the passage through them of the electric current to their melting temperature and to observe how this quantity depends upon the diameter of the wire.

b—To find the per cent elongation of a nickel wire when raised from room temperature to its melting temperature.

c—To ascertain the carrying capacity in amperes of nickel wires of different diameters when raised by the passage of the current to the melting point, the wires being in still air and lying horizontal.

d—To find the resistivity of pure nickel when at a temperature just below melting.

For obtaining the above information from a single experiment the device and electrical circuits shown in Fig. 1 were devised.

The wire to be tested was stretched between two binding posts *pp'*. These posts were mounted on a board *B* covered on the top side with asbestos sheet for protection against burning. A spring *S* was hooked to the wire at its middle point, which would raise it up when it increased in length on heating by an amount *h*. The height *h* by which the spring raises the wire was measured with a steel scale. Then from a knowledge of the length *l* and the height *h* the length *l*₁ is easily calculated and consequently the percentage increase in length

may be at once determined from the relation $\frac{l_1 - l}{l} \times 100 =$

per cent increase in length. Provision for heating the wire till it reached its melting point and broke was made by passing through it alternating current derived from a transformer with voltage tap-off points, the cur-

rent being further regulated with a control rheostat. A wattmeter was introduced in the circuit and also an ammeter in the manner clearly shown in the figure.

Since the melting point of pure nickel is accurately known, namely, 1452 deg. C., it is evident that if the current through the wire is slowly increased until the wire melts and the circuit opens, its temperature at this moment must be very approximately the melting temperature of nickel. If furthermore, the length and diameter of the wire is known and the wattmeter and the ammeter are read just before or at the instant that the wire melts and the height *h* be also measured, all necessary facts are known for calculating; the per cent increase in length of the wire in being raised from room temperature to its melting point, the watts being dissipated per cm² from its surface when at its melting temperature, the maximum number of amperes which it can carry in still air and the resistivity of nickel, just as it reaches its melting point.

The resistivity of the wire is given by the formula

$$P = \frac{\pi r^2 W}{L F} = \text{resistivity of nickel at melting temperature.}$$

In this formula *r* is the radius of the wire obtained with micrometer callipers and *L* its length. Strictly speaking *L* should be taken as the length which the wire has attained at the moment of melting, but the error is very slight if the distance between the binding posts *pp'* is taken as the length of the wire. This distance was in all cases 50 cm. *W* is the watts read on the wattmeter and *I* the current read on the ammeter.

In obtaining the data the writer was assisted by several students. He is indebted to Mr. H. F. Porter for working up the data into convenient form for exposition.

Wires of four different sizes were tested and where in the second, seventh and eighth columns of the table of results two figures appear these represent the figures obtained from two independent experiments made on wire of the same size.

All the essential data and results which were obtained are embodied in the table given below.

DATA AND RESULTS
All wires 50 cm. long between binding posts. Ni melts at 1452° C.

Wire Diameter in Cms.	Total Dissipation Watts	Rate of Spring in Cms.	Total Length of Wire in Cms.	Per Cent Increase in Length	Total Surface Area in Sq. Cms.	Watt/cm ²	Max. Carried Amperes	Resistivity at Melting Point, Microhms	Times Increase in Resistivity
0.0246	270	6.5	1.6	3.22	4.003	67.5	6.21	61.5	6.7
0.051	475 465	5.8 5.8	1.32	3.22	8.273	56.75 56.22	16.7 16.5		
0.0755	650				12.28	52.74	29.15		
						52.12	28.70		
0.109	900 940				102.3	32.26 32.71	63.0 63.3		

Precision attained probably between 1 and 2 per cent.

The following points may be mentioned: The results give the very upper limits of current and watt-carrying capacity of a rheostat constructed in the very common form of winding a wire in a spiral. Possibly nichrome, which is said to melt at a slightly higher temperature than nickel, would carry a little more.

The results give the very maximum of watt dissipation in still air of straight horizontally stretched nickel wires. In round numbers one may say that 50 watts to the square centimeter of heat dissipating surface is about the ordinary limit of wires having the high melting point of nickel. Of course, if resistance wires are wound on cylinders as in resistance furnaces and packed round with heat insulating material they will dissipate but a small fraction of the watts and carry but a small fraction of the current given in the above table of results which apply only to the condition of

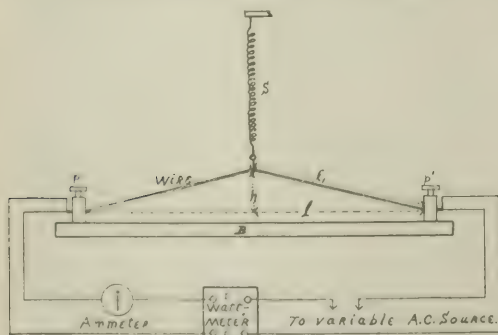


FIG. 1. EXPERIMENTAL ARRANGEMENT

the wire being stretched in a horizontal position in still air.

It is very interesting to note that wires of small diameter can get rid of their heat per square centimeter at about twice the rate that a wire of large diameter can.

The method above described would not be applicable with any degree of precision to wires made of metals which oxidize rapidly, such as copper. However, the oxidation might be prevented by plating wires of a readily oxidizable metal with nickel.

The increase in the resistivity of nickel in passing to the melting point from room temperature is about 6.7 times its resistivity at room temperature. It is highly probable that on melting the resistivity suddenly doubles, though I am not aware that this determination has been made in the case of nickel.

The per cent increase in the length of the wire was 3.22, an amount quite sufficient to cause a nickel wire wound tightly on a cylinder of refractory material to loosen up badly when brought to a high temperature. It is this fact that makes it generally unsatisfactory to endeavor to secure furnace resistance wires firmly on a refractory cylinder by covering them over with a refractory cement. The cement generally scales off, due to the expansion of the wire.

Notes on Copper Smelting at the United Verde Copper Company

(Editorial Correspondence)

The new smelting plant of the United Verde Copper Company, erected in 1914-15, is situated at Clarkdale, Ariz., in the valley of the Verde River, about 5 miles distant and 2000 ft. below the town of Jerome, where the old plant was situated.

The Clarkdale smelter is equipped for both reverberatory and blast-furnace smelting by the most approved modern methods, and although erected primarily to treat the company's own ores, it is available for smelting such custom ores as are offered from the district. Blast-furnace smelting is the more important operation, with regard to tonnage treated, but the reverberatory furnaces are a valuable adjunct for smelting fine ore and flue-dust.

TABLE I. CONSTITUENTS OF BLAST-FURNACE CHARGE

	Iron Ore	Silica Ore	Grade Ore	Converter Clips	Lime- stone
Cu per cent.....	5.5	5.8	0.8	9.5	—
SiO ₂ per cent.....	11.5	22.0	70.0	16.0	6.0
Fe per cent.....	33.0	26.0	17.0	17.0	—
S per cent.....	37.0	25.0	1.2	6.5	—
CaO per cent.....	—	—	—	—	50.00



FIG. 1—GENERAL VIEW UNITED VERDE SMELTER, CLARKDALE, ARIZ.



FIG. 2—SAMPLE MILL, UNITED VERDE SMELTER

The company's mine affords three types of ore, making a mixture that is largely self-fluxing, and in addition thereto a high grade of limestone is obtained from a local deposit. Typical analyses of the three classes of ore are given in Table I. The most important is a heavy sulphide, well suited to blast-furnace treatment. The second type is a more silicious sulphide, and the third an oxidized highly silicious ore. At the smelter these ores are designated as iron, silica and oxide respectively. The last is used not only as a constituent of the blast-furnace charge, but portions of it are so highly silicious as to be useful for converter flux and reverberatory fettling. An important characteristic of the United Verde ore is its remarkable freedom from arsenic and antimony.

Blast Furnace Smelting

An uncommon feature of the blast furnaces is the Giroux hot-blast top, in which air is preheated before going to the tuyeres. This was a characteristic of the furnaces at the old plant at Jerome and has been retained. The first cost of construction is, of course, greater than for furnaces with brick superstructure, and additional power is required to force the air through the pipes; but the company's metallurgists are convinced that definite advantages accrue from this construction in the increased temperature of the blast and convenience of operation. The economy and efficiency of hot blast have long been realized in iron smelting, where the inflammable gases evolved from the furnace are used as fuel in preheating air. Since no such gases are evolved in any quantity in copper matting, economy of heat in smelting is sought by preheating the blast in separate U-pipe stoves or in specially constructed furnace tops like the Giroux. The advantages claimed for hot blast are reduction in the percentage of coke required, conservation of heat and acceleration of reaction between the components of the charge. With the Giroux construction the charge may be smelted with hot top without risk of damaging the furnace superstructure.

Table II shows a typical blast-furnace performance on run-of-mine ore for a twenty-four hour period. Blast pressure is 30 oz. The coke used contains 22 per cent ash, and the quantity averages about 6 per cent of the weight of the charge. Copper on the charge is about 5 per cent and sulphur about 25 per cent. The matte will average 23 per cent copper. A typical slag analysis is given in Table III.

Blast-furnace gases are conducted by two flues from each furnace to a dust chamber running parallel with the furnace building. The interior of this chamber is fitted with baffles that give the gases a tortuous path throughout the entire length. The bulk of the dust is recovered here, and the gases continue through a short flue to the 400-ft. brick-lined steel stack. Analysis of the flue dust is given in Table IV.

Roasting and Reverberatory Smelting

The roasting plant for fine ore comprises six six-hearth, air-cooled Wedge furnaces, 21 ft. 6 in. in diameter, with rabble arms traveling at the rate of about one revolution in two minutes. Auxiliary oil burners are provided which are portable to the several hearth doors. These are for occasional use when the ore is coarse or low in sulphur, or for any other reason not roasting properly. No limestone is added to the furnace charge. Feed will average 28 per cent sulphur and the calcine 8 to 9 per cent. Under these conditions each furnace shows a capacity of 90 tons in twenty-four hours, and the entire battery is operated by a 30-hp. motor. Flue dust is collected in a chamber fitted with plate and wire baffles.

Reverberatory furnaces are 19 ft. wide by 100 ft. long. One of the three is constructed for charging through hoppers arranged above the side walls. The other two are charged through central hoppers in the



FIG. 4—CONVERTER ROOM, UNITED VERDE SMELTER

usual manner but have side hoppers for fettling material. Each furnace has two 700-hp. Stirling waste-heat boilers which, however, can be oil-fired independently of furnace operation.

The furnaces also are oil-fired, using California crude oil under a feed pressure of 60 lb. and at a temperature

TABLE II—TYPICAL BLAST-FURNACE TONNAGE, 24 HR.

Tons	Material
217	Iron ore
218	Silica ore
20	Oxide ore
18	Limestone
32	Converter slag
515	
29.7	Coke = 5.8 per cent of charge

TABLE III—SLAG ANALYSES

	Blast-Furnace	Reverberatory
SiO ₂ per cent.....	39.0	38.0
FeO per cent.....	42.0	43.0
Al ₂ O ₃ per cent.....	9.5	12.0
CaO per cent.....	2.5	0.5
Cu per cent.....	0.2	0.35

TABLE IV—CONSTITUENTS OF REVERBERATORY CHARGE

	Calcine	Blast-Furnace Flue-Dust	Silica Ore Fettling
Cu per cent.....	6.5	9.0	4.0
SiO ₂ per cent.....	21.5	21.0	80.0
Fe per cent.....	32.0	30.0	4.0
S per cent.....	9.3	11.0	1.5

of 170 deg. Fahr. Air is delivered to the nozzles at 15 lb. pressure. Reverberatory capacity is in excess of present requirements, but on the completion of a proposed crushing and screening plant at the tunnel mouth a larger quantity of fine ore will require reverberatory treatment.

Analyses of materials charged to the reverberatories are given in Table IV, and a typical reverberatory tonnage for twenty-four hours in Table V. The oil con-

TABLE V—TYPICAL REVERBERATORY TONNAGE, 24 HR.

Tons	Material
232	Calcine
62	Blast-furnace flue-dust
39	Silica ore fettling

sumed in smelting the 333 tons of charge indicated was 262 bbl., giving a fuel ratio of 0.79 bbl. per ton of solid charge. The quantity of converter slag delivered to the furnace is not recorded, nor are any figures available from which to credit the fuel ratio with heat utilized at the boilers. With this credit applied the fuel consumption would appear much lower. Reverberatory matte is higher grade than that from the blast furnaces, averaging 35 per cent copper.



FIG. 3—400-FT. STEEL STACK, UNITED VERDE SMELTER

Basic Converting

The converting equipment consists of five stands and eight shells of the Great Falls type, 12 ft. in diameter and lined with magnesite. The output is 80 tons of copper per day. Silicious ore used for converter flux has approximately the same composition as that shown for reverberatory fettling in Table IV. Two tons of ore is used in the converters for every ton of copper produced. Air is supplied at 15 lb. pressure from several blowing units, the latest of which is a turbo-blower running at 2500 r.p.m. and having a capacity of 24,000 cu. ft. of free air per minute.

The blister copper produced at the United Verde smelter is 99.25 per cent pure, and as stated before is remarkably free from arsenic and antimony. It is taken from the converters in 10-ton ladles and cast into 365-lb. bars in two casting machines. Converter slag is charged both to the reverberatory furnaces and blast-furnace settlers.

Earlier mention was made of a proposed crushing and screening plant at the mine. The construction of this plant will benefit both blast-furnace and reverberatory operations. For the former it will insure the delivery of raw ore free from fine material, thereby making for increased tonnage, reduction in flue dust, and possibly a lower consumption of coke. For the reverberatories it will afford a supply of material more nearly equal to the present furnace capacity.

Smelting operations of the United Verde Copper Company are under the direction of Mr. Thomas Taylor, superintendent, and Mr. H. N. Thomson, metallurgist.

Some Technical Applications of Capillary and Electrocapillary Chemistry*

BY W. C. MCC. LEWIS, M. A., D. SC.

Capillary chemistry, as the name suggests, deals with phenomena which occur at the surface or interface which separates two phases. The term "surface" or "interface," in this connection, does not refer to the mathematical concept of a surface (which has no physical existence). What is meant is the very thin interfacial layer caused by the interpenetration of both phases, which extends to a very slight depth, not exceeding the effective range of molecular attractions, that is in all probability a few millionths of a centimeter.

It might be thought that effects which are limited to such dimensions would never play any significant rôle in physico-chemical phenomena. This is true up to a certain point. Given the proper conditions, however, surface effects play not only a significant, but even a decisive part in the observed phenomena. The necessary condition is that the surface shall be large compared to the mass or bulk of at least one of the phases. Under this condition it is to be expected that the force known as surface tension may lead to the production of phenomena not observable when the phases which constitute the system are present in bulk.

To illustrate the point, let us consider the phenomenon of adsorption. Suppose we have an aqueous solution of, say, sugar in contact with an oil in which both sugar and water are insoluble; then, if the presence of the sugar modifies the interfacial tension between the oil and the water, it will be found that the concentration of the sugar in the interfacial layer is not identical with its concentration in the bulk of the solution. This surface-concentration effect is denoted by the term adsorption to distinguish it from absorption which means the distribution of the solute throughout the entire bulk of a phase.

The phenomenon of adsorption is one of the most important and characteristic features of capillary chemistry. It was first put on a sound theoretical basis by Willard Gibbs, who showed that the phenomenon depended upon the effect produced by the dissolved substance upon the value of the interfacial tension between the two immiscible phases. Gibbs proved by thermodynamic means that if a dissolved substance was capable of lowering the interfacial tension, then the substance would be positively adsorbed at the interface; that is, its concentration in the surface layer would be greater than its average concentration in the bulk of the same phase. On the other hand, if the dissolved substance was capable of raising the interfacial tension it would suffer adsorption at the surface; that is, its surface concentration would be less than its average concentration in the bulk of the phase.

One can test Gibbs' expression by forming an emulsion of, say, hydrocarbon oil in an aqueous solution of some substance which is quite insoluble in the oil in the ordinary sense, but which has the property of lowering the interfacial tension oil-water. It will be found that the concentration of the dissolved substance throughout the bulk of the water is less than its concentration previous to the formation of the large interface produced by emulsifying the oil. That is, some of the substance is now closely adhering to the oil-water interface at a higher concentration than that possessed by it in the bulk of the water. The bulk concentration has consequently been depleted to allow of the adsorption layer being formed. Two conditions are postulated in Gibbs' deduction: first, the phenomenon must be reversible; that is, if the concentration of the solute in the bulk of the aqueous phase be diminished the surface concentration must likewise diminish; and secondly, the bulk concentration must not exceed the limits of applicability of the perfect gas laws.

The reference of the term emulsions suggests two other kinds of systems very similar in nature and behavior, namely, suspensions and colloidal solutions. Suspensions, emulsions, and colloidal solutions are all ultimately governed by the same laws. They are all fine-grained systems, possessing large interfacial area compared to the mass of the disperse phase. Suspensions represent systems having the largest size of particles (diameter approximately 10^{-4} cm.), emulsions come next with diameter of the order 10^{-5} cm., and colloidal solutions represent the highest stage of subdivisions, with particles the diameter of which is usually of the order 10^{-6} cm.

It is an important though not easily understood fact that great variation in size of the particles in one and the same system renders the system an unstable one, with the result that the particles, instead of remaining in permanent distribution throughout the liquid medium, agglomerate or coagulate, giving rise to a jelly-like mass, called a gel to distinguish it from the stable suspended state, which is termed the sol.

Since suspensions, emulsions and colloidal solutions are characterized by the possession of large interfacial area, it is obvious that adsorption effects may take place upon the particles of these systems just as in the case of porous bodies possessing large surface area, such as charcoal, textile fabrics, paper, sand, and soil. Suspensions, emulsions, and colloidal solutions possess, in addition, certain well-marked characteristics more particularly associated with the phenomenon of their stability in the disperse or sol form, and the conditions which determine the conversion of the sol into the gel.

The first point is the determination of the average size of particles in a colloidal solution, or what amounts roughly to the same thing, the apparent molecular

*A paper read before the Liverpool Section of the Society of Chemical Industry. From the issue of May 31, 1916, of the *Journal of the Society*.

weight of the colloid in the sol form. From the fact that colloid particles are invisible under a high-power microscope, Bredig inferred that the diameter must be less than 10^{-4} cm. From the fact that colloidal solutions possess the property of polarizing light, Lobry de Bruyn concluded that the diameter could not be less than 5×10^{-6} cm.; that is, of the order 10^{-5} to 10^{-7} cm. Other considerations, also based upon optical effects, have led to the value 5×10^{-6} cm. for the average diameter of colloidal metals. As regards molecular weight, the result of applying the ordinary osmotic expression—which, by the way, seems to be a perfectly justifiable procedure in view of the work of Perrin and others—has led to enormous values: e. g., 5000 for gelatin, 15,000 for albumin in water.

A further point of interest is the so-called Brownian movement, exhibited by suspended particles, and due to the bombardment of the particles by the molecules of the medium. Although this phenomenon is of great theoretical interest, it is not proposed to consider it further in this place, since in the few technical applications of capillary chemistry which it is proposed to deal with later no explicit use of the phenomenon is made.

We may now pass to what is probably the most important phenomenon in connection with colloids, namely, the *electric charge* which the particles possess and the mechanism of *coagulation*, which is intimately connected with the removal of the electric charge. Practically all particles in the stable colloidal or emulsoidal state are electrically charged. In aqueous solution, colloidal metals, sulphides, and oil emulsions are negatively charged, while colloidal hydroxides and many organic substances are positively charged.

The sign of the charge is most conveniently determined by placing the colloidal solution or emulsion in a U-tube fitted with platinum electrodes, and observing the direction of motion of the particles under the applied electromotive force. This movement is termed *cataphoresis*. When the particles arrive at the electrode, which is naturally charged in the opposite sense to that of the particles themselves, the latter are discharged, and coagulate together to form a gelatinous mass at the electrode which is easily distinguishable by the eye.

It is a remarkable fact that the removal of the charge should bring about coagulation. The simplest view of the matter, though probably an inadequate view, is that coagulation is prevented by the electrostatic repulsions of charges of the same sign, and that when the repulsion is removed by the discharge the accidental impacts of the now uncharged particles result in the building up of large aggregates which are precipitated by the action of gravity.

That gravity does not cause the precipitation of individual particles, even apart from their charge, is probably due to the fact of Brownian movement, the particles being retained in suspension in virtue of the bombardments by the molecules of the medium.

A matter of the greatest uncertainty is the problem of the ultimate source of the electric charge, which the particles carry.

We know that colloids can be discharged and coagulated, not only by contact with an oppositely charged electrode, but also by means of electrolytic ions of opposite sign, the coagulating effect of such ions increasing generally with their valency. Thus Al^{+++} ion, which possesses three positive charges, is a better coagulant of a negatively charged colloid, such as colloidal arsenic sulphide, than is Ba^{++} , which carries two positive charges; and this, in turn, is much more effective than a monovalent ion such as Na^{+} .

In view of the fact that ions can bring about dis-

charge, it has been inferred that the charge in the first place was conferred by the adsorption upon the surface of the colloid of one of the ions of the medium, say H^{+} or OH^{-} , when water is the medium. Such a view as this receives considerable support from the behavior of a colloid such as albumin, which has been shown by Hardy to be neutral, or nearly so, in pure water, positively charged in acid solution where H^{+} is in excess, and negatively charged in alkaline solution where OH^{-} is in excess. I am inclined to think, however, that albumin is rather a special case. The difficulty of accepting the ionic-charge view as a sufficient one is evident when it is remembered that colloidal solutions may be obtained in media in which it is difficult to believe that ions exist. Thus Billiter has prepared colloidal platinum in chloroform, in which the colloid is electrically charged; and what is equally remarkable, the charge is a positive one, although in water colloidal platinum is negatively charged. Further, the process of spraying liquids through an orifice into a vacuum, or into a gas, confers a charge upon the particles. This process is hardly distinguishable from the more familiar cases of frictional electricity.

In my opinion, the origin of the charge carried by a colloid or emulsion particle is the same as that which we recognize as frictional electricity. In this connection it is very significant that in general the sign of the charge carried by a particle is determined by the relative values of the dielectric constant of the disperse phase and the medium the phase which possesses the higher dielectric constant being the positively charged one. Now, water is a substance with a characteristically high dielectric constant, and it is to be anticipated, therefore, that in the majority of emulsions and colloidal solutions which contain water the water will be positively charged with respect to the particles; or, what is the same thing, the particles will be negatively charged with respect to the medium. Although one can obtain positively charged colloids in water, it can probably be stated that the majority of colloidal solutions in water contain particles which are negatively charged.

It would be rash, however, to believe that dielectric constant is the only determining factor. Even granting the frictional idea, we are still met with the difficulty of visualizing with any degree of clearness the relative distribution of the opposite charges existing respectively on the particle and upon the neighboring molecules of the medium. The usual view is due to Helmholtz, and is, therefore, spoken of as the "Helmholtz double-layer" theory. According to this, a colloid particle and the surrounding layer of molecules of the medium can be regarded as a small condenser with a certain potential difference between the surface of the colloid and the nearest layer of molecules.

But this does not really take us very far unless we postulate something further about this system. It will be observed that a system represented by a charged colloid particle surrounded by a layer of oppositely charged molecules is, strictly speaking, electrically neutral as far as an external field of force is concerned. An effective charge can only be produced in such a system if there is a certain amount of "give" between the nucleus and the outer layer; and the fact that colloids do move in an electric field is evidence that such a "give" takes place.

Lamb (Phil. Mag., 1888) is practically the only investigator who has attempted to deal quantitatively with this point by introducing a factor called the "facility of slip" into his expression for the potential difference across the "double layer."

It is obvious that any attempts to determine the actual charge carried by a colloid particle are very liable to

error. What we do measure is the much smaller quantity, namely, the *effective* charge, which is dependent upon the magnitude of the facility of slip. If the facility of slip were zero, that is, if there were no "give" between the layers, the colloid-condenser system would possess no effective charge at all, though the true charge upon the particle might be considerable. The results of such determinations have hitherto been very discordant, and we really do not know with any certainty the true charge on a colloid particle.*

Although this is the case with regard to the charge, the value of the potential difference between the colloid particle and the surrounding medium is much more accurately known. We are particularly indebted to E. F. Burton (Phil. Mag. 1906) for having carried out the first quantitative measurements in this direction. As a rough approximation, one may say that the potential difference amounts to 0.05 volt for practically all colloids and emulsions. The determination of this potential has great significance for the phenomenon of coagulation, for it has been found that by addition of a suitable electrolyte it can be reduced to zero, and may even be carried through zero to real values of opposite sign.

The position at which the potential difference is zero has been called by Hardy the isoelectric point, and it was considered that this corresponded to the optimum condition for coagulation, or what is the same thing, at the isoelectric point the colloid is most unstable. Although this is nearly true, the actual coincidence of iso electric point and maximum instability has been called in question. This problem is, therefore, in a state of considerable uncertainty.

A similarly unsatisfactory state of things exists in relation to the discharging effect produced by ions when we come to examine the phenomenon closely. It is easy to conceive of a positive ion, such as Al^{+++} being absorbed upon a negative colloid and discharging it, but what rôle are we to attribute to the negative iron originally associated with the Al^{+++} ion? It is known, for example, that aluminum sulphate possesses a different coagulating power from aluminum chloride—but why? We can only say that we do not know. Even the recent work of Bancroft (Trans. Amer. Electrochem. Soc., 1915, 27, 175), which has increased our knowledge of such phenomena very considerably, does not get us further than the conclusion that there is a specific adsorption effect entering in all cases, specific not only with respect to the ions, but likewise with respect to the colloid. It is clear that an immense field lies untouched in such problems as these.

Before passing from the problem of electric charge and coagulation it is necessary to deal very briefly with the closely allied phenomena of *colloid-protective effect* and *peptonization*. It is well known that a colloidal solution of platinum in water can be rendered much more stable by the addition of a small amount of gelatin. The gelatin acts as a preservative. In this case, one colloid stabilizes or protects the other. In the phenomenon of peptonization we have what may be described as the reverse of coagulation. That is, certain gels may be converted into sols by the action of reagents. Thus the gel hydroxides of zinc, aluminum, and chromium can be converted into the sol form by addition of excess of caustic potash. It is to Bancroft (loc. cit) that we owe the idea that protective effect and peptonization are one and the same thing.

To illustrate the point, a sentence or two may be quoted from a recent paper by Bancroft (l. c.) dealing

with the behavior of mixtures of chromic and ferric salts with excess of alkali: "Hydrous (hydrated) chromic oxide is peptonized by caustic potash, while hydrous ferric oxide is not. If the chromium salt is present in large amount relatively to the iron salt, the ferric hydroxide will absorb the peptonized chromic hydroxide and be peptonized by it, thereby going apparently into solution. If the ferric salt is present in excess it will absorb the peptonized chromic hydroxide, carrying it out of the liquid phase. It is to be noticed that the chromic hydroxide, when in excess, acts as a so-called protective colloid to the iron hydroxide."

There still remains one other phenomenon of capillary chemistry, the importance of which is very great, both from the scientific and technical standpoint, namely, the phenomenon of *electro-osmosis*, or *endosmosis*. By electro-osmosis is meant the movement of a liquid through a membrane or through a capillary tube toward one of the electrodes when the membrane or tube is placed in an electric field of force between the two electrodes. The phenomenon is due to the fact that at the glass-liquid interface there is a potential difference, due to charges of opposite sign resident upon the glass, and the neighboring molecules of the liquid. These charges are not rigidly fixed, and can, therefore, slip from one molecule to another, in a sense, parallel to the axis of the tube.

It has long been known that if water be placed in a vessel divided in half by a vertical, porous membrane, and an electrode be placed in each half, then the water will move through the membrane under the influence of the external e.m.f., so that the level rises in one half and falls in the other. This phenomenon is similar to cataphoresis, with this difference: that in cataphoresis the liquid medium remains approximately stationary during the passage of the suspended particles through it, while in electro-osmosis the medium itself moves, the diaphragm being fixed.

From what has been said already regarding the origin and magnitude of the electric charge on colloid particles it is obvious that our knowledge of the phenomenon of electro-osmosis is somewhat unsatisfactory. In this, as in other applications of capillary and electrocapillary chemistry, technical practice is considerably ahead of theory.

Some Applications of Capillary and Electrocapillary Chemistry to Chemical Industry

The following list, which is by no means exhaustive, will serve to illustrate the variety of technical processes in which capillary effects play an important rôle:

- Rubber preparation. Vulcanization.
- Separation of ore constituents.
- Sprayers for crops. Soil fertility.
- Rôle of colloidal iron in plant growth.
- Medicinal emulsions. Milk. Cream formation.
- Beverages. Liquid foods. Enzymes. Inorganic ferments.
- Peptonization. Clotting. Physiological fluids.
- Emulsions for photographic purposes.
- Gums and adhesive materials.
- Inks and marking fluids. Pigments.
- Dyes and dyeing. Bleaching, tanning, staining.
- Paper sizing and coloring. Carbon and other copying papers.
- Soap manufacture and cleansing action.
- De-emulsification of water in steam turbines.
- Filtration processes. Peat drying, etc.
- Sewage treatment. River sludge. Charcoal purifiers.
- Colloidal metals in fused melts. Ruby glass. Opaque glass. Enamel.
- Cement. Mortar. Plaster.

*For a fuller discussion of the problem see the chapter on colloids contained in the author's "System of Physical Chemistry" in Sir William Ramsay's series of text books.

Rôle of colloids in electrolysis.

Contact catalytic processes.

A few of the problems involved in some of the above applications of capillarity will be considered under the following heads: (a) general capillary principles; (b) technically important emulsions and colloidal solutions; (c) adsorption; (d) coagulation; (e) selective adsorption (of ions); (f) protective effect; (g) electro-osmosis.

(a) Application of General Capillary Principles to Certain Technical Problems

As an example, we may consider the theory of wetting and the *determination of wetting power*. This is of great importance, especially in agricultural practice, since it is a determining factor in the efficiency of liquid sprayers. A special case has recently been examined by Cooper and Nuttall (J. Agric. Science, 1915, 7, 219-230). These investigators point out that the efficiency of a spraying liquid is not solely dependent upon the amount of toxic substance present, the wetting power being of equal importance.

The wetting power depends upon the value of the interfacial tension between two phases, this value determining whether a liquid, A, will wet or run over the surface of a second liquid or solid, B. The value of the interfacial tension can be modified by adsorption phenomena, since positive adsorption necessarily accompanies a decrease in tension. The lower the tension the greater the wetting power.

To get efficient spraying it is, therefore, necessary to have present some substance which markedly lowers the tension. For this purpose, soap, or a substance having a "soap basis," is particularly suitable, and is, therefore, recommended by these authors.

(b) Technically Important Emulsions and Colloidal Solutions

One of the most important emulsions we have already referred to in sprayers, or spraying liquids. These usually consist of an oil of some kind emulsified with water which contains a substance possessing toxic properties, such as basic copper salts, in the case of potato spraying to prevent potato blight. In such cases as these the emulsion which is formed by mechanical means is very far from being uniform, and can scarcely be regarded as stable. In the case of medicinal emulsions, such as cod liver oil emulsion, the preparation is carried out with greater care, a much more uniform and therefore more permanent emulsion resulting. Artificial beverages are, for the most part, emulsions or colloidal solutions. Cocoa and coffee, for example, may be regarded as emulsions, tea as a colloidal solution. The production of tannin-free tea depends upon the fact that the colloidal tannin can be coagulated and separated. As regards natural emulsions, the most important of all is, of course, milk. Milk is only a moderately stable emulsion, and in many respects this is a decided advantage, otherwise cream might have remained an unknown commodity.

Another exceedingly important emulsion which occurs naturally is rubber latex. Reference will be made to this later in dealing with its coagulation.

Besides colloidal solutions in which the liquid medium is usually water or aqueous solutions, there are a number of others which are only liquid in the sense of being mobile at relatively high temperatures. I refer to glasses and enamels. Ruby glass, for example, is a very beautiful illustration of a true colloidal solution of extremely high viscosity, the colloid being a metal, the medium a mixture of fused salts. Many such colloidal solutions have been known for centuries. Among recent

preparations of such solutions may be mentioned that of translucent glass. Such substances, however, are of very complex composition, so that while one feels justified in instancing them as examples of the colloidal state it must at the same time be confessed that the knowledge we possess of colloids is far too limited to be of much use in dealing with complex cases and still less with suggesting improvements on rational lines. It would appear that empirical methods must unfortunately be relied on for perhaps a long time yet in such cases, for the lag between theory and practice is unfortunately great.

The question of photographic emulsions will be briefly considered in dealing with electro-osmotic processes.

(c) Technical Applications of Adsorption

Technical processes in which adsorption plays an essential part are very numerous. In the place of first importance one should mention *dyeing* processes. It is now fairly generally recognized that the first stage in such processes is a true adsorptive one. Dyestuffs are generally characterized by exerting a very marked lowering effect upon surface and interfacial tension. It follows therefore from Gibbs' principle that they are largely adsorbed, with the result that in the surface layer (which probably does not exceed 10^{-6} cm. in thickness) the concentration of the dye becomes great, eventually exceeding the limit of solubility which it possesses in the ordinary sense. The result is that precipitation or coagulation takes place and this in many cases is accompanied or succeeded by ordinary chemical combination with certain of the amphoteric substances present in the material to be dyed.

It is clear, of course, that adsorption cannot cover the whole phenomenon, for adsorption in the sense of Gibbs' theory is a reversible process, while dyeing is essentially an irreversible process, the fastness of the dye being dependent upon the fact of irreversibility.

In the case of *tanning* the process is very similar. A reference will be made to tanning later from the standpoint of electro-osmosis. It will be observed that in dyeing and tanning we are dealing primarily with the adsorption of colloidal matter upon a surface, most dyestuffs such as Congo red belonging to the group of so-called "electrolytic colloids," that is the colloidal part functions as an ion (anion).

Bleaching processes, while being fundamentally adsorptive in nature, differ from the preceding cases in that the bleaching agent is not usually a colloid and therefore its effect upon the surface is a better defined chemical process. A bleaching agent such as sodium hypochlorite lowers the surface tension of water and hence is positively adsorbed at the surface.

Surface-adsorption of molecules and ions of electrolytes plays a fundamental rôle in *agricultural problems*. One of the results so far obtained in this very complex subject is the conclusion that the general character of a soil is as much governed by the size of grain, that is, by the surface area of the soil particles, as by their chemical nature. Heavy clay means small porosity, and therefore small surface and small adsorbing power for salts and non-electrolytes dissolved in the water present. The result is that this material is unsatisfactory. The function of adsorption in soils is to retain the soluble salts from being washed away too far from the surface of the ground during heavy rain. The extent to which adsorption occurs depends not only upon the soil but also upon the nature of the fertilizer. The question of the efficiency of fertilizers would lead us too far, but that the problem is fast becoming an exact applied science is very evident. It is clear on general grounds that capillary chemistry plays a great rôle in such prob-

lems, as we have already seen in connection with the theory of wetting, but it is to be feared that many of the workers in this field have not fully realized the significance of capillarity for the processes concerned.

A further important technical application of adsorption is found in the methods of *water and sewage purification* in so far as *filtration* is concerned. The functions of porous substances such as charcoal and sand are so familiar that they need not be considered at length. It is sufficient to point out that capillary adsorption is the fundamental factor, though, as in dyeing and tanning, the irreversibility of the process is an essential, and in so far as irreversibility exists the phenomenon is not covered by the simple capillary theory. Purification problems also come under the head of coagulation of colloids and a brief reference to them will be made there.

Another field in which adsorption plays a part is that of the *cleansing action of soap and the clarification of liquids*, such as wines. In the case of soap there is no doubt that the alkali produced as a result of hydrolysis acts as a peptoniser or emulsifier for the fatty matter which is to be removed, and the intimate contact, which is necessary to attain this, is possibly brought about by the fact that the soap, both unhydrolyzed and as colloid ions, depresses the interfacial tension with the result that adsorption of the soap takes place and capillary wetting occurs easily.

In the case of clarification processes the results of a particular investigation may be cited as illustrative, the object being to find a good clarifying agent for certain wines which would be effective without altering the taste appreciably. According to F. La Marca (see this Journal, 1915, p. 1066), "experiments with nine types of Italian wines indicate that fish glue was the best clarifying agent." The tannin and extract content can be reduced by adsorption upon the fish glue without altering other constituents. "Egg albumen is also an excellent clarifier and does not alter the composition of the wine." Aluminous earth markedly reduces the acid content and also the extract, but not the color or the tannin. "Acidity and color are diminished by charcoal, which also reduces the tannin to a slight extent." The specific effects of adsorption upon surfaces of different nature manifest themselves here very clearly.

(d) Application of Coagulation Principles

Coagulation, as already pointed out, is brought about by removing the electric charges which are situated upon the colloid or emulsion particles and which go to maintain these in a stable sol form. The discharging process is most conveniently carried out by means of electrolytic ions of opposite sign to that possessed by the colloid. The colloid may also be discharged by being carried to an electrode, the discharge at the electrode being presumably quite analogous to the discharge of an ion in ordinary electrolysis. It is of some interest to consider one or two large scale applications of both of these methods of producing coagulation. First of all, coagulation by ions.

A very important application of this is found in one of the methods employed for rectification of current—that is, the transformation of alternating into direct current. In this connection the *aluminum rectifier* is well known. A condenser is placed in the alternating-current line, one plate of the condenser being of aluminum, the space between the plates being filled with an aqueous solution of a salt. On the aluminum plate there is rapidly formed some colloidal aluminum hydroxide, and if this can be made to coagulate and adhere to the plate the current taken off will be unidirectional.

The problem is, therefore, to choose an electrolyte

which will most completely effect the coagulation of the colloid. Since aluminium hydroxide is a positively charged colloid the discharging effect must be brought about by an anion, and further as we have seen the higher valency of the ion the more effective it will be. Thus the salts of monovalent acids—such as nitrates, chlorides, acetates, etc., are inefficient. Salt of divalent acids, such as sulphates, carbonates, and tartrates, are moderately efficient. That is to say, a rectifier containing such divalent salts will rectify current whose voltage does not exceed 30-50 volts. If the current is at a higher voltage the rectification is only very partial and incomplete. Using trivalent radicles such as phosphates, citrates, or borates, the efficiency of the rectifier is much increased, as it is now capable of dealing with a pressure of over 200 volts. It is interesting to note, also, that silicates, though strictly speaking belonging to a divalent acid, are exceedingly efficient, no doubt due to the fact that the coagulation is here itself functioning as a colloidal anion though a clear explanation of the mechanism is wanting.

Obviously much investigation remains to be done. It would be interesting to try other colloidal anions of much greater complexity than colloidal silicate, such, for example, as organic, electrolytic colloids like Congo red. The point as to whether the molecular mass of the coagulation is significant as well as its valency also requires investigation.

Another important application of coagulation is met with in the *de-emulsification of water contaminated with oil*, the oil being in the form of an emulsion. It is an important engineering problem, especially in connection with the forced lubrication in steam turbines, and has been solved with some considerable success by the use of alum. The oil particles are negatively charged and can, therefore, be discharged by a cation of high valency such as Al^{+++} . The alum solution is run slowly into the emulsion, the oil coagulates on the top and may be run off. The result is that a considerable quantity of oil is recovered which would otherwise have run to waste, and at the same time the oil is prevented from fouling the heated parts of the engine. It may be remarked that oils, otherwise very similar, differ much in the ease with which they become emulsified (cf., for example, A. Philip, *Journal Society of Chemical Industry*, 1915, 34, 697).

The next problem to be touched upon is *river sludge formation and sewage precipitation*. The fact that material which remains in suspension as long as the liquid medium is fresh water but is deposited when carried to the mouth of a river where the medium is now salt, obviously suggests that coagulation has been brought about by the sodium and calcium salts of the sea water. When this process goes on for centuries formation of deltas results. As a rule, coagulation of this kind is anything but desirable. In other cases, however, notably when a river overflows its banks, the result may be beneficial. The fertility of the Nile valley, for example, may be ascribed to this cause, the rich colloidal matter in the river water being precipitated upon the adjacent soil.

In view of the large amount of sewage annually carried down by rivers the question has been raised as to whether it may be possible to recover by means of regulated coagulation some of the valuable fertilizing materials represented by the phosphorus, nitrogen and potassium contained in the sewage. As a matter of fact, an attempt has been made along these lines in Germany, but so far the efficiency is low. It is nevertheless a very important problem. Our present practice of getting rid of sewage somehow can scarcely be the last word on the subject.

As a final illustration of coagulation by chemical means, that is by ions or even by change in the nature of the solvent by large addition of non-electrolyte, a reference may be made to one or two methods for the *coagulation of rubber latex*. A method suggested by Fulton and Macallum (Eng. Pat. 9066 of 1914) depends as far as I see upon the change in the nature of the medium. The latex suspended in water is treated with aldehydes or ketones other than formaldehyde. As an example 80-90 parts of water are added to 10-20 parts of aldehyde or ketone and the solution may be used with about half its volume of latex which is preferably sprayed over the coagulant. An alternative method of treatment which causes coagulation and at the same time sterilizes the rubber is that proposed by S. C. Davidson (Eng. Pat. 22,138 of 1914). A solution of one part of sodium thiosulphate in 16 parts "alkalised cresol," that is, a solution of cresylic acid in aqueous sodium or potassium hydroxide, is stirred into Hevea latex in the proportion of 1 to 5 per cent. The latex is allowed to stand for 24 hours, and is then coagulated by means of a 1 to 2 per cent solution of sulphuric acid. Other acids, such as acetic, trichloroacetic, or hydrochloric may be used. The SO_2 evolved on addition of the coagulating acid possesses a preservative effect upon the rubber.

It is somewhat obscure why it should be necessary to allow the latex to remain so long in contact with the thiosulphate. The thiosulphuric acid may, of course, exert an incipient coagulating action, or it may be that the thiosulphate requires this time to take the place of other salts already adsorbed upon the latex particles. That is to say, it may be a case of preferential or selective adsorption. I have no idea as to how efficient this actual process may be. It serves, however, to indicate how much purely scientific work remains to be done in order to supply us with a larger number of general principles which would serve as guides in this or other colloid problems.

Let us turn now to the alternative method of colloid coagulation by bringing the colloid directly into contact with an oppositely charged metal electrode. This has had up to the present less utility than the ionic method. De-emulsification may be easily effected upon the laboratory scale, but I do not know if it would compare with the alum method on the large scale. The method, however, has been employed for sewage treatment. According to A. M. Williamson (Trans. Amer. Electrochem. Soc., 1915, 27, 193) an installation in America deals with as much as a million gallons of sewage per day. On general grounds one would think that the electrical method should be efficient in that all the colloidal material would automatically separate itself at both electrodes according to the sign of the charge. The method would, however, be more economic of current the smaller the content of electrolytic salts present.

(e) Selective Adsorption

This principle has been made use of in a method proposed for the *separation of radioactive salts* (Ges. für Elektro-Osmose, Eng. Pat. 10,083 of 1914). The salts are in a state of adsorption upon colloid material, this condition being the result of a preliminary treatment. The point is to remove the adsorbed radium salts as completely as possible from the colloid material and from other salts, e.g., barium. This is effected by adding to the colloidal solution certain other salts at suitable concentration. These salts are preferentially taken up by the colloid, the radium salt thus passing into solution.

By way of illustration, a MnO_2 adsorption product of Ra and Ba in a fine state of subdivision is boiled

with NH_4Cl solution of certain strength and the solution filtered. On analysis it is found that the solid matter contains 32.7 per cent of the Ba and 64.7 per cent of the Ra originally present. That is, a certain amount of separation of Ra and Ba has been effected. Although a single run leads only to a partial separation the method is interesting and suggestive.

(f) Application of the "Protective" Effect

Reference has already been made to the protective and preservative action of gelatin upon colloidal platinum. In a process patented by the Gesellschaft für Elektro-Osmose (Eng. Pat. 9261 of 1914), the object of which is to *prepare stable colloidal solutions of metals* in general, use is made of *colloidal silicic acid* as the protective colloid. The silicic acid is obtained in a pure state by a method which will be referred to later.

As an example of the procedure adopted, a metal salt, i.e., a silver or gold salt, is reduced by a suitable reagent such as hydrazine hydrate in presence of the silicic acid. A stable solution of silver or gold results, which is purified from the electrolytes by electrolysis. In a later patent (Eng. Pat. 15,267 of 1914) it is claimed that the protective effect of silicic acid can be extended to the preparation of stable metals prepared by Bredig's sparking method, the instance quoted being nickel. Further applications of the salt-reduction method in presence of silicic acid deal with the preparation of colloidal selenium, palladium and platinum. It would appear, therefore, that the method is a fairly general one.

A further instance of protective effect is to be found in a process for *sizing and coloring parchment paper* (E. Fues, Eng. Pat. 19,816 of 1914). A solution which contains both an acid and a basic dyestuff may in general be regarded as an unstable one. In the presence of some size, however, precipitation can be prevented, the size acting as a protective colloid. The mixture of dyestuffs can therefore be successfully applied, in this case, to the paper.

(g) Applications of Electro-osmosis

This is one of the most important branches of applied electro-capillary chemistry. As an example of a general type of problem to which electro-osmosis is applicable one may instance *filter press* work. In this connection F. Ulzer (Z. angew. Chem., 1915, 28, i. 308), describes a process whereby filtration of liquids containing very fine particles can be made without clogging the filter cloth. The filter is of the usual form, consisting of a number of chambers in each of which electrodes are placed. The chambers are first filled with liquid, the current is passed, and the suspended matter wanders to one or other of the electrodes, becomes electrically discharged, and is deposited. The liquid can now be made to pass with relative ease through the filter cloth. Clogging of the latter is thus largely diminished, and hence excessive pressure is not required. The author claims that the method separates the finest particles from liquids and can be used for mineral colors, dyestuffs, barium sulphate, and other suspensions. Strictly speaking, the process is an illustration of cataphoresis and coagulation rather than electro-osmosis, but the arrangement is very similar to that employed in electro-osmotic problems generally.

A second instance is the application of electro-osmosis to the preparation of pure colloids, the case in point being the preparation of *colloidal silicic acid* of low molecular weight, that is, in a state of fine subdivision (Ges. für Elektro-Osmose, Eng. Pat. 9273 of 1914). To begin with, an alkali silicate solution of 5-10 per cent strength is placed in an anode compartment, the electrodes being preferably perforated. When the prod-

uct is to be used medically the anode consists of platinum gauze. Brass wire net serves as the cathode, the electrodes being separated by an electrically neutral membrane, consisting of carborundum and corundum. The process begins with low voltage, which is ultimately raised to 60–70 volts to remove all the alkali from the compartment. The colloidal silicic acid negatively charged,* is precipitated at the anode, the sodium leaving the compartment. Traces of foreign acids present with the silica are removed by transferring the solution to a vessel serving as a cathode and electrolyzing, the anode being surrounded by parchment.

A further illustration of the applicability of electro-osmosis deals with the *tanning of hides and impregnation of similar materials*. In the usual method of tanning the material is brought into contact with the tanning liquid under suitable conditions of concentration and temperature, and allowed to remain in contact for a length of time. In the present process (Ges. für Elektro-Osmose, Eng. Pat. 19,849 of 1914) the tanning action is accelerated and possibly improved by bringing the tanning colloid into very close contact with the hide by electrical means. The hide is kept at a suitable potential, positive or negative, and the tanning substance, which is naturally charged, moves up to and is discharged upon the surface. A few details are given in the abstract (this J., 1915, 34, 1021), and are as follows:

"Hide is tanned by electro-osmosis by utilizing the material to be treated as a partition, without fitting it tightly to the walls, to divide the space between suitable diaphragms, the latter being so selected that the active constituents cannot migrate through them, whereas substances affecting the osmotic action unfavorably pass through and are separated from the liquid. Constituents which hinder or delay the process are removed from the hides or skins electro-osmotically by desorption before the actual tanning. During treatment the hides or skins are caused to acquire automatically a potential suitable for the tanning substances used; with tannin this must be of an electro-positive character, with chromium compounds, electro-negative."

As a final example of electro-osmosis we may briefly consider the manufacture of *gelatin for photographic emulsions* (Ges. für Elektro-Osmose, Eng. Pats. 21,448 and 21,484 of 1914). The object is to get a gelatin free from fat and from mineral and reducing constituents. The procedure is as follows: A solution of gelatin inclosed between electrically indifferent diaphragms is subjected to an external voltage. The inorganic ions migrate through the diaphragms in the ordinary way and so are removed. At the same time any albuminoid bodies are coagulated and can be mechanically separated off. The resulting gelatin is thus free from turbidity which sometimes manifests itself owing to the presence of albumin. Exactly the same procedure is applicable to the manufacture of *high grade glue*. Modifications may be introduced in the form of electrically charged diaphragms for the separation of other constituents, thereby yielding a very pure product.

From the survey given above it is evident that the subject of capillary and electrocapillary chemistry is one of great magnitude and importance both from the scientific and from the technical aspects. In the present situation it is plain that technical application has considerably outrun theory, and if future industrial development is not simply to be on empirical lines, it is essential that scientific investigation must be greatly accelerated. At the present time capillary chemistry does not occupy the place it should in our University

curricula. But as things stand it is impossible to deal with the subject effectively. From the manufacturers' standpoint, a serious lesson might be drawn from the activities of a single German firm, the Gesellschaft für Elektro-Osmose, from whose patents several illustrative examples have been taken. It is fairly evident that such processes can only be dealt with and extended by proper scientific control. It has been repeated *ad nauseam* that this is the only way to advance not only in regard to the applications of capillary chemistry, but in all applied chemistry. It does not, however, appear, even yet, to have been sufficiently realized.

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The Active Materials and Electrolyte of the Alkaline Storage Battery

BY L. C. TURNOCK

The materials that function electrochemically in the alkaline storage battery and are employed in its manufacture are nickelous hydrate, $\text{Ni}(\text{OH})_2$, for the positive plates, metallic iron containing a small amount of mercuric oxide, HgO , for the negative plates and an aqueous solution of caustic potash containing a small amount of lithium hydrate as electrolyte.

Preparation of Nickelous Hydrate

Shot nickel varying in size from approximately 1/16 to 1/4 in. in diameter is dissolved in sulphuric acid. The process is continuous, more nickel and acid being added as the solution containing the nickel as sulphate is drawn off. The hydrogen gas evolved in the reaction is retained and conducted to a gasometer; it is subsequently employed in the reduction of ferric oxide to metallic iron.

The nickel sulphate solution contains as impurities small amounts of copper, arsenic, antimony and iron. The bulk of the copper is removed electrochemically by shot nickel, while the remainder together with the arsenic and antimony is precipitated out with hydrogen sulphide gas. The solution is filtered and the iron in the filtrate oxidized to the ferric state with bleaching powder or sodium hypochlorite (NaOCl), the former being used most. The solution is carefully neutralized with soda ash, when the iron precipitates out approximately as a basic sulphate.

The filtrate containing the nickel as sulphate is sprayed by gravity into copper-lined wooden or iron tanks containing a 10 to 15-per cent solution of sodium hydrate, which has been previously brought to the boiling point by means of steam coils placed in the bottom of the tanks. The nickel is thrown down as the nickelous hydrate. The function of spraying the nickel sulphate solution into hot caustic soda is to prevent as far as possible the occlusion of any sulphate by the precipitate, thereby minimizing the amount of subsequent washing required to purify the nickelous hydrate.

The clear liquid is drawn off and the $\text{Ni}(\text{OH})_2$, removed as "mud" and filter-pressed by means of wooden filters. The product contains small amounts of sodium sulphate, sodium hydrate, sodium carbonate and water, all of which must be removed. It is placed in pans and dried by steam coils; the temperature is not allowed to exceed 100 deg. C. An analysis of the dried product averages

Water (in vacuum over Sulphuric Acid) ..	1.33%
Nickelous hydrate	52.54%
Sodium Sulphate	30.34%
Sodium Hydrate	12.41%
Sodium Carbonate (from soda ash)	3.30%

*It is not quite clear what sign the charge possesses under these circumstances. Usually SiO_2 sol is negative, but becomes positive in acid solution.

The mass is leached with hot distilled water (steam condensate) ten to twelve times until the wash water shows no test for sulphates, carbonates, nor gives an alkaline reaction. No attempt is made to wash out the impurities from the nickel hydrate "mud." The filter pressing and subsequent steam drying of the product renders it more porous and permits of more efficient washing and in addition the washing is accomplished in a shorter period.

Following the washing of the nickelous hydrate it is dried by steam coils, the temperature not being allowed to go over 100 deg. C. The product is now tested for its electrical capacity (see below) and if found up to standard ground up in 500-lb. batches. Of the screened material that which is desirable comes between 30 and 190 mesh. The allowable limits for acceptance of material is not over 6 per cent through a 190 mesh sieve and not over 15 per cent upon a 30 mesh sieve. All of the ground product generally passes a 20 mesh. The material is now ready for loading into the tubes that constitute the positive plates of the battery.

Preparation of Metallic Iron

The purest iron obtainable (generally a Norway or Swedish product) is employed as a starting product; it shows on analysis traces of manganese, phosphorus, silicon and sulphur with carbon as low as 0.02 to 0.03 per cent. The raw material is placed in lead-lined digesters and treated with sulphuric acid. The gases evolved, consisting of hydrogen, hydrocarbons and hydrogen sulphide are conducted through a purifying train containing sodium hydrate to remove the hydrogen sulphide and chromic acid to remove the hydrocarbons. The hydrogen is conducted into the same gasometer in which is stored the hydrogen obtained as a by-product in the purification of the nickel. The resulting ferrous sulphate solution is drawn off and crystallized and re-crystallized several times, after which the crystals are put into a centrifugal machine to free from the mother liquor and subsequently into rotary driers fired with fuel oil to a temperature of 200 to 300 deg. C.

The dried and slightly calcined ferrous sulphate is placed in muffle furnaces and given an oxidizing roast. The resulting product is ferric oxide (Fe_2O_3), which is leached out with water to remove traces of ferrous sulphate not affected by the roast. After drying the oxide of iron is placed in iron retorts and set in a muffle furnace and reduced to metallic iron by the hydrogen obtained above. As an index to determine when the reduction of the ferric oxide is complete the charge is weighed as put in and the moisture formed in the reaction condensed, collected and weighed.

The vessels containing the metallic iron are removed from the furnace and allowed to cool in an atmosphere of hydrogen gas to prevent almost spontaneous ignition back to the oxide. As a further precaution against reversion back to Fe_2O_3 , a dilute solution of NaOH (to prevent rusting) is run in on top to cover the iron when the pan is opened. The product is allowed to stand five to six hours in the sodium hydrate solution, when it is drained and dried slowly by heat. After grinding and mixing with 6 per cent of yellow oxide of mercury (which is prepared by dissolving mercury in nitric acid and precipitating it out again with NaOH solution) it is ready to be tested for its electrical capacity and if found up to standard loaded into the pockets that make up the negative plates of the battery.

The beneficial action of the mercuric oxide in

maintaining the activity of the iron appears to be more or less empirical in character. It is reduced to metallic mercury during the charging of the battery as is evidenced by the fact that an examination of the sediment in the bottom of the containers of cells that have been in service for some time frequently discloses the presence of appreciable amounts of metallic mercury that have fallen from the pockets. Small amounts of iron oxide that may be present in the iron through an incomplete reduction of the Fe_2O_3 will lower the capacity of the latter; the presence of mercury seems to counteract this detrimental effect. Moreover, metallic mercury will increase the electrical conductivity of the mass.

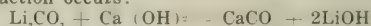
Preparation of Electrolyte

The electrolyte employed is made up according to two sets of specifications. One calls for "first" electrolyte, which goes into the cells after assembly, and consists of an aqueous solution of potassium hydroxide (21 per cent by weight) containing 50 grams of lithium hydrate per liter of finished electrolyte. This amount of lithium hydrate represents its maximum concentration in a 21 per cent KOH solution at 24 deg. C. The specific gravity of "first" electrolyte is about 1.230 at 20 deg. C.

The second specifications call for "renewal" electrolyte, which is supplied for renewal after the cells have been in more or less continuous service for about a year. It is made up of an aqueous solution of KOH (25 per cent) and 15 grams of LiOH per liter of finished electrolyte. Fifteen grams of lithium hydrate, likewise, represents the maximum concentration in a 25 per cent potassium hydrate solution at 24 deg. C. The total alkalinity of such a solution, computing the LiOH in equivalence of KOH, is 27.8 plus or minus one-half per cent.

The potassium hydroxide employed is an electrolytic product of potassium chloride and is received as a solid in iron drums. It is dissolved and diluted to a 33 per cent solution and subsequently to solutions corresponding to 25 and 21 per cent, respectively. The specific gravity of the solution is employed as a measure of its strength; 21 per cent KOH has a specific gravity of 1.2026 at 17.5 deg. C. and 25 per cent KOH of 1.248 at 20 deg. C.

The lithium is obtained as the carbonate and dissolved in water in large steam-heated iron kettles and treated with lime (CaO) and hot water. The following reaction occurs:



The calcium carbonate is allowed to settle and a solution containing about 4 per cent LiOH is obtained; it is bluish in color and very caustic. The 4 per cent LiOH solution is concentrated down until about a 12 per cent solution is obtained, when it is analyzed for its LiOH content and its gravity taken. The calcium oxide (CaO) is obtained by calcining a very pure grade of limestone in a kiln fired by producer gas and air.

The following example illustrates the method of computing and making up the electrolyte according to specifications:

Given a 33 per cent KOH solution having a specific gravity of 1.320 and 12 per cent LiOH solution having a specific gravity of 1.14.

Required to find the proportion in which to mix the above two solutions in order to obtain a solution containing 21 per cent of KOH and 50 grams of LiOH per liter of finished electrolyte.

Solution.—One liter of 33 per cent KOH contains
 $1.320 \times 1000 \times 0.33 = 435.6$ grams KOH

1 liter of 21 per cent KOH (Sp. Gr. equals 1.202) contains

$1.202 \times 1000 \times 0.21 = 252.42$ grams KOH
Therefore, volume of 33 per cent KOH solution required to supply 252.42 grams of KOH equals
 $252.42/435.6 \times 1000 = 579$ c.c.

1 liter of LiOH solution contains

$1.114 \times 1000 \times 0.12 = 133.68$ grams LiOH
Therefore, volume of 12 per cent LiOH solution required to supply 50 grams of LiOH equals
 $50/133.68 \times 1000 = 374$ c.c.

Hence, specifications for 1 liter of 21 per cent KOH plus 50 grams per liter is

33 per cent KOH.....579 c.c.

12 per cent LiOH.....374 c.c.

Water (supplied).....47 c.c.

The specifications for making up the solution containing 25 per cent KOH plus 15 grams of LiOH per liter is obtained in a similar manner.

While the battery is in service more LiOH appears to enter the plates on discharge than is given out on charge. Inasmuch as the lithium hydrate seems to exercise a beneficial effect upon the battery in proportion to the amount present in the electrolyte, it is desirable to maintain the concentration of the LiOH at a maximum. For this purpose crystals of lithium hydrate (containing about 54 per cent LiOH), and varying in amount from about 9 grams for the smaller sizes of batteries to over 100 grams for the larger types, are placed in the cell after assembling and just before the "first" electrolyte is added.

Testing of the Nickelous Hydrate and Iron for Electrical Capacity

By electrical capacity of the active material is meant the length of time a certain amount of it, loaded into tubes or pockets similar to those constituting the finished plates, will deliver a specified current by the time its potential falls to a certain predetermined value. The selection of this value is entirely arbitrary and is influenced by the electromotive force characteristics of the two electrodes upon discharge and by the performance of motors, or other electrical appliances to be operated, under the decreasing potential gradient of the battery. It is usually selected to conform to conditions encountered commercially and down to which the battery will show its best service; if allowed to fall lower, it will have little or no practical importance.

Theoretically, a cell containing 1.042 grams of iron and 1.725 grams of nickelous hydrate will furnish 1 amp.-hr., but after a discharge of 1 amp.-hr. it will have no capacity, and its potential will have dropped to a value which cannot be utilized at all. Practically, the battery must have enough excess active material in its construction to insure its potential not falling below a certain arbitrary value while discharging at a certain desired rate and immediately after it has delivered its predetermined capacity in ampere-hours.

Another important factor which affects the available capacity of the battery is temperature. The potential of the battery when delivering its normal rate current is a function of its internal resistance and decreases with increase of resistance. A rise in temperature, however, will decrease the internal resistance and thereby allow of a greater ampere-hour output before the cell will have reached the predetermined cut-off voltage. Consequently, in determining the electrical capacity of the nickel hydrate and iron it is essential that the temperature at which the test is made is the same as that under which the

standard test was made. In order to fulfil the requirement that the cell will not drop below a certain potential before it delivers its rated output, approximately 4.64 times as much Ni(OH)₂ and 5.78 times as much iron are used in the construction of the different plates as the theoretical minimum.

To determine whether or not the active material as manufactured is standard in capacity, tests are made with miniature cells. Those for testing the hydrate of nickel are composed of one tube loaded with the hydrate under question and two pockets, containing some standard iron, mounted on either side of the hydrate tube. Those for testing the iron consist of one pocket containing the iron under question together with two tubes, one mounted on either side of the iron pocket, containing some standard nickel hydrate.

The nickel hydrate is placed into a standard-size tube by an automatic loading machine, which alternately adds and tamps in the hydrate of nickel and flake nickel (very thin squares of metallic nickel about 0.00004 in. thick and 1/16 in. on the edge). The weights of both entering the tube are noted; the flake nickel averages from 13 to 14 per cent of the weight of the total contents.

The electrolyte employed for the test cells is a 21 per cent KOH solution containing 11.2 grams of LiOH per liter of finished electrolyte. Based on their relative capacities the amount of electrolyte employed in the test cells is greater than that used in the commercial sizes; hence, an electrolyte containing less lithium hydrate is employed.

The charging and discharging rates used represent practically the same current density as that recommended for the larger types.

A loaded tube, 3 in. in length, will contain about 7.75 grams of both nickel hydrate and flake nickel in approximately 265 alternate layers of each.

The cell is put on three cycles of charge and discharge at room temperature, charging for 15 hr. at 300 mil-amperes and discharging at 200 mil-amperes down to a terminal voltage of 0.9, noting the capacity in mil-ampere hours in each case. The available capacity will usually increase after each cycle; this is no doubt due to increased penetrability of the active mass by the electrolyte, thereby rendering more of it active. The first three runs are followed by ten cycles of charge and discharge, the cell being kept at a temperature of about 54.5 deg. C.; it is discharged to zero voltage in each instance.

The operation of the cell at such a temperature, which is rarely attained in practice, is thought to hasten its deterioration and multiply the severity of the service it will ordinarily be put to under commercial conditions. At higher temperatures, moreover, tests show that both the nickel hydrate and iron have a low effective input on charge, the former exhibiting this phenomenon more decidedly than the latter; obviously, this would result in a lower available capacity. As a matter of fact, however, four subsequent runs similar to and at the same temperature as the first three generally show the cell to have increased in capacity. Such a cell must show at least 1100 mil-ampere hours before the active material is accepted.

For testing the activity of the iron approximately 5 grams are placed in one of the standard pockets and mounted in a test cell. For the first three runs it is charged for 15 hr. at about 0.4 amp. and discharged at 0.3 amp. down to 1.0 volt, noting the capacity in each instance. On the next three runs it is charged at 0.4 amp. and discharged at about twice the former rate down to 0.5 volt, noting capacities

at both 1.0 and 0.5 volts. This is generally followed by two cycles of charge and discharge at same rates as employed for the first three runs, noting the available capacity at both 1.0 and 0.5 volt. A procedure of this character will demonstrate the desirability of the iron. A pocket containing 8 grams of acceptable iron will show better than 1900 mil-ampere hours discharged to 1.0 volt.

An analysis of the terminal voltage of the battery discharging at its normal rate, as typified by the employment of an auxiliary electrode, shows that the potential of the negative plates, or those originally containing iron as active material, is practically constant. This is indicative of the fact that the iron, in addition to being present in greater equivalent amounts, is more active electrochemically than the nickel hydrate, no doubt due to its greater porosity and consequent greater accessibility to the ions of the electrolyte.

This is further substantiated by the fact that the curve representing the difference of potential on discharge between the positive plate, or that originally containing the nickelous hydrate as active material, and the auxiliary electrode has the same general shape as the curve showing the terminal voltage on discharge at normal temperatures. The available capacity of the battery is limited by the behavior of the positive plates on charge and discharge.

Furthermore, owing to the material composing the positive plates having a small electrical conductivity as compared with that composing the negative plates, very thin flakes of metallic nickel are incorporated with the nickelous hydrate in alternate layers in the tubes, pressure being applied after each separate addition to insure more intimate contact between the active material and the walls of the tube; such a process increases the conductivity of the mass as a whole. Obviously, a decrease in electrical resistance cannot be secured by this means except at a sacrifice of the porosity of the active material and consequent accessibility of the electrolyte ions to the interior of the mass.

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Synopsis of Recent Chemical and Metallurgical Literature

Conveyor Belts

Testing of Conveyor Belts.—From an extended paper on conveyor belts for metallurgical plants, published by A. ROBERTSON and A. MCARTHUR JOHNSTON in the *Journal of the South African Institution of Engineers*, we take the following excerpt relating to methods of testing conveyor belts. The authors advocate the practice of such tests in order to raise the standard of materials used, and as a protection against poor material and excessive charges.

Balata Belts

Balata belts are tested by determining the strength of the warp and filler of the canvas, and by ascertaining the frictioning or adhesion between adjoining plies or layers. In belting the main strength must lie in the warp, though that of the filler should be but little inferior. This strength is found by breaking in the tension machine a section of the belt one inch in width. Care must be taken in cutting this that no thread in the line of the pull be broken before the test.

(1) *Strength of Cotton Duck.*—When for some reason only one ply can be obtained for this test it is advisable to cut a section just over an inch, and detach therefrom single strands until the exact inch is got.

The grips also must bear evenly over a surface, so as to avoid pinching the belt in one place; this may be partly avoided by making the gripped portion larger than an inch—say one and a half inches, with a taper to one inch. The tested portion should be, over the inch section, at least three inches in length.

A specification for the cotton duck used in this belting should note:

- (a) The weight of duck used (ounces per linear yard).
- (b) The number of yarns per inch, both for warp and for filler.
- (c) The tensile strength of the warp and of the filler.
- (d) The amount of stretch in the belt.
- (e) The number of plies in the belt.

To illustrate the variation that exist among this class of belting, the samples being submitted for one particular duty, I may quote the following results:—

Samples tested lengthways of belt (warp). Tensile Strength of Total Belt, one inch in width.

	Number of Ply
(a) 2,806 lb.	8
(b) 3,180 lb.	8
(c) 3,168 lb.	8
(d) 3,564 lb.	6
(e) 3,600 lb.	4
(f) 3,916 lb.	8
(g) 3,136 lb.	8
(h) 1,420 lb.	6

If we neglect the last one as being an inferior lot, we still find a variation amounting to over half a ton per inch in the breaking strain of the different duck used; this means an additional load capacity of 15 tons on a 30 in. belt.

The tensile strength of the filler in certain belts examined shows proportionately even greater differences.

Samples tested, one inch in width.

	Number of Ply
(a) 900 lb.	6
(b) 1,440 lb.	8
(c) 2,288 lb.	10
(d) 1,980 lb.	8
(e) 1,684 lb.	8
(f) 1,584 lb.	8
(g) 1,232 lb.	8

The difference of a breaking strain of 750 lb. per one inch section in the filler of two eight-ply belts is surely worthy of consideration when placing an order.

It is to be noted that the strength of the warp is greater than the filler, and agents should note in submitting samples for test that these be at least 10 to 12 inches in length and about 3 to 4 inches in width, except when the strength of both warp and filler is required, in which case the section submitted should be 10 inches square.

(2) The *adhesion* between adjacent plies of duck is determined by maintaining a steady pull in separating these. A section of the belt one inch in width is taken, and one, or even two or three, of the plies is separated by hand from the remainder for a length of two inches, and the two ends caught in the clamps of the machine shown in Fig. 1 (testing machine). A steady pull is applied by turning the wheel, the rate of turning being regulated so that the jaws may move apart two inches per minute.

The spring balance registers the resistance set up and indicates the effectiveness of the Balata frictioning. The adhesiveness depends on the quality and quantity of the Balata used and the success of the operation known as frictioning.

The Pennsylvania Railroad Company require that the frictioning of their air brake hose be such as to support a pull of 25 lb. while separating at approximately the above rate. Many air hoses on our market scarcely maintain a 11-lb. pull when separating contiguous plies.

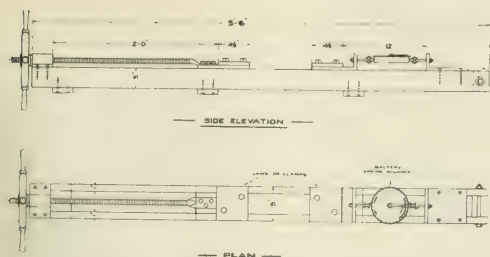


FIG. 1—TESTING OF CONVEYOR BELTS

A specification for Balata belts might well demand a friction test of at least 20 lbs. This figure is not often reached here, but if demanded it could easily be got, and would form some guarantee that the belt plies would not readily come asunder.

The following results from a series of tests show actual figures on samples of Balata belt at present in this market:—

Friction Tests

	Lbs.
(1)	21 1/2
(2)	21
(3)	24
(4)	18 1/2
(5)	17
(6)	16 1/2
(7)	15
(8)	14
(9)	13
(10)	12
(11)	11
(12)	5

(3) The *stretch* in the belt is not often determined in the testing laboratory, though, given suitable apparatus, this could be easily done. It is always advisable to test the belt as a whole and not over an inch section.

Rubber Conveyor Belts.

Similar tests are made on rubber conveyor belts, with, of course, the additional testing and analysis of the rubber.

(1) *Canvas Strength*.—Owing to the greater cost of rubber belting, firms are not keen on supplying test lengths of 9 to 12 inches, and as a rule tests of the cotton duck are made on the transverse section. One sample of a very good belt submitted here gave the same tensile strength longitudinally as transversely, but this result would not always be found.

The following are the records of the *total strength* of the cotton duck of seven belts recently examined here:—

	Lbs.
A. Tensile strength on 1 in. transverse section (6 ply)	902
B. Tensile strength on 1 in. transverse section (6 ply)	858
C. Tensile strength on 1 in. transverse section (6 ply)	924
D. Tensile strength on 1 in. transverse section (6 ply)	825
E. Tensile strength on 1 in. transverse section (6 ply)	1,050
F. Tensile strength on 1 in. transverse section (6 ply)	990
G. Tensile strength on 1 in. transverse section (6 ply)	1,350

The *friction tests* on these same seven samples showed that none of them were exceptionally good, while one was exceedingly bad, and three poor. The tests were made on a one inch transverse section.

	Lbs.
H. Friction test between cotton duck layers	10
I. Friction test between cotton duck layers	14 1/2
J. Friction test between cotton duck layers	14
K. Friction test between cotton duck layers	15
L. Friction test between cotton duck layers	8 1/2
M. Friction test between cotton duck layers	9
N. Friction test between cotton duck layers	6

As these results were obtained from belts which are reckoned the best on our market, it would seem that neither the cotton duck used nor the frictioning are as strong in rubber conveyor belts as in Balata belts.

(2) *Rubber layer*.—The value of the rubber layer depends entirely on the quality of the rubber used, on

the vulcanizing it has received, and on its age. One has to handle rubber constantly to realize the depreciation that takes place in this climate, and more especially with the quality of the rubber used for this class of work. It is in my opinion essential in buying a belt to stipulate that it has been but recently imported. Not only does the rubber deteriorate, but the frictioning material used to cement it to the duck loses its adhesive properties.

Two belts which were tested here showed that the rubber layer in each case lost its elasticity to a not inconsiderable extent after a lapse of six months.

Thickness of layer, 3/16 in.

Elongation of a section 1 in. wide and measuring 3 in. between the grips, before breaking.

Q	11 1/2	18 1/2	18 1/2
R	11 1/2	18 1/2	18 1/2

The following results were obtained from seven samples of rubber conveyor belts:

	Incombustible Matter in Rubber, per Cent	Stretch of 3-In. Test Piece, Inches	Friction Test Between Rubber Layers, Lbs.
Q	18.50	1 1/2	12
R	16.05	1 1/2	3
S	42.00	10	6 1/2
T	65.10	5	14
U	37.07	8	9
V	44.04	8	15
W	59.34	8	
X	39.00	8	

Sample W.—The rubber layer in this sample refused to be detached from the canvas layer. As soon as a grip could be obtained and a moderate pull exerted, the rubber tore showing both the poorness of the quality and the effect of climatic conditions.

The elasticity or stretch in the rubber layer is obtained by gripping a section 1 in. wide in the machine used for the friction test, with a distance of 3 in. between grips. The total elongation before breaking or tearing is thus obtained, as is also the tensile strength of the rubber. The following may be quoted as characteristic tensile strengths of a 1-in. section of the rubber layer of belts in good or fairly good condition and ready for the market here:

	Stretch of Rubber (3 In. Between Grips), In.	Tensile Strength, Lbs.
Q	10	8 1/2
R	7	6 1/2
S	12	1 1/2
T	5	12
U	9 1/2	10 1/2
V	8	10
W	8	240

It would be recommended, therefore, that a specification should demand:

(a) That the incombustible matter in the rubber layer be under 50% by weight.

(b) That a section of the rubber layer 1 in. in diameter shall stretch to at least three times its own length before breaking (3 in. to 9 in.).

(c) That the frictioning between any two contiguous layers, rubber and canvas or canvas and canvas, be at least 15 lb.

It is probable that in time these demands could be made more stringent.

Plastic Flow

Laws of Plastic Flow.—Information on plastic flow is important to many industries. The Bureau of Standards has recently conducted investigations on the laws

of plastic flow and published the results as Scientific Paper No. 278. The author of the paper is EUGENE C. BINGHAM. The property of plasticity, like ductility or malleability, is not at present strictly definable, although the term is much more familiar than the strictly defined terms "viscosity" and "fluidity."

In the study of plastic flow it has already been shown that most homogeneous solids will flow somewhat after the manner of liquids, if subjected to sufficient pressure. Copper, steel, lead, ice, menthol, glass, and asphalt fall in this class in so far as they may be regarded as homogeneous solids. But ordinarily plastic substances are not homogeneous solids, but suspensions of finely divided solids in fluids, such as paint in oil, lime in water, and especially clay in water. Numerous papers have been devoted to the explanation of this latter type of plasticity.

Since glass and other similar bodies are often regarded not as solids but as very viscous liquids, the demarcation of viscous flow from plastic flow has not been sharply made. In fact, attempts have been made to give numerical values to the viscosity of ice, menthol, glass, and pitch, and Tammann defines plasticity in a perfectly definite manner as the reciprocal of viscosity—in other words, plasticity and fluidity are synonymous.

Unfortunately, for the sake of simplicity, this definition is clearly untenable. If any finely divided solid, such as clay, be suspended in a liquid, the fluidity is lowered rapidly and in a perfectly linear manner, so that at a comparatively low concentration of clay the fluidity, as measured in the ordinary viscometer, approaches zero. Thus Durham and Bingham found that a certain clay suspended in water gave a zero fluidity when the volume percentage had reached 6.95 (14.6 per cent by weight), this being independent of the temperature. This concentration apparently serves to sharply demarcate plastic from viscous flow. Suspensions more dilute than this critical concentration are subject to viscous flow, while those containing more solid in suspension are plastic.

The experiments of Bingham and Durham support the definition of Maxwell that a plastic body is one in which the form of the body is found to be permanently altered when the stress exceeds a certain value. However, the laws of plastic flow must be known before a rational basis can be obtained for the quantitative measurement of plasticity. The work of the bureau, which was done chiefly on English china clay, is summarized as follows:

The various types of viscous and plastic flow have been considered theoretically. According to the circumstances of the flow the viscosities may be additive, the fluidities may be additive, or slipping or seepage may enter in to affect the character of the flow. The possible separation of the components of a mixture by means of flow has been considered. It has been shown that in a suspension of solid particles in a liquid there must be a dissipation of energy when the solid particles collide, as they must collide if the layers of the suspension move over each other. This dissipation of energy follows the laws of ordinary friction and not the laws of viscosity.

Measurements have been made upon the flow of clay suspensions of different concentrations through capillaries of varying dimensions and at two temperatures.

It is shown that plastic flow can be sharply differentiated from viscous flow by the "friction" necessary to start plastic flow. The friction is a linear function of the volume concentration. It is also affected by the presence of alkalis or acids, but it is independent of the length or diameter of the capillary as well as the temperature of the medium.

For medium pressure the rate of efflux is given by the formula

$$v = K(P - f),$$

where P is the pressure, f is the friction, and K is an arbitrary constant. The experiments indicate that at low pressure seepage takes place causing a perceptible change in the concentration, and that at high pressures there is slipping which under certain circumstances may cause a sudden increase in the rate of flow.

The fluidity becomes zero at the concentration of solid where the plastic flow begins; that is, where the friction begins to have a positive value. This concentration, where the particles are able to form a bridge across the capillary space, is reached long before the concentration corresponds to close packing of the solid particles. For very fine-grained material the range between the concentration giving zero fluidity and the concentration corresponding to close packing will be much greater than in coarse-grained material.

The "mobility" of suspensions has been defined and calculated. The mobility decreases very rapidly from its maximum value in the concentration which has zero fluidity to a value not far from zero in the mixture which corresponds to close packing of the solid particles. The mobility increases with the fluidity of the medium, but is also greatly affected by the presence of alkalis or acids.

Recent Chemical and Metallurgical Patents

Iron and Steel

Accurate Determination of Critical Point During Annealing.—An apparatus for accurately determining the critical point during the annealing operation, and thus affording a more accurate control of the grain size and other properties of iron and steel, is patented by ROY B. FEHR of State College, Pa. The method consists in magnetizing the work under treatment and noting any quick change in the magnetization by a millivoltmeter. When iron or steel reaches the critical point it is no longer magnetic, and thus this point can be determined accurately and need not be estimated or a thermo-couple with its inherent temperature lag need not be depended on, which give varying results in heat treatment.

The apparatus used is shown in Fig. 1. An ingot P is placed in an electrically heated resistance furnace 4. The furnace here shown is heated by a core of nichrome ribbon 3 wound around refractory material. An iron yoke 6 is connected with the ingot, and the yoke is magnetized by the coil connected with resistance 13. A millivoltmeter 10, connected to copper coil 11, serves to indicate the critical point.

In operating, to find the critical point of the heat curve, the exciting current is adjusted by the rheostat 13 until the ammeter reading is of a proper value to produce a flux of suitable density in the magnetic circuit. The switch 12 is then closed and the reversing switch 9 is opened; the momentary large deflection of the millivoltmeter is then read. This reading is proportional to the change in magnetic flux from, say, plus 14,000 units with the magnetizing current to a "residual" flux of, say, plus 7000 units with no magnetizing current. Switch 9 is then closed in the opposite direction, and a reading is obtained corresponding to a change in flux from plus 7000 to minus 14,000 units. These operations are repeated at regular intervals during the heating process, and thus there may be obtained two sets of observations, one set for breaking the circuit and the other for making the circuit. One set would be sufficient, but the other set gives a reliable

check on the work. When the readings in either set suddenly begin to increase or decrease (according to whether the magnetic induction is above or below the "knee" of the saturation curve of steel) I have a positive indication that the metal in the hottest part of the furnace is becoming non-magnetic and ready for heat treatment. (1,188,430, June 27, 1916.)

Operation of Reverberatory Iron-Melting Furnaces.—In melting iron for foundry use in reverberatory furnaces, a uniform temperature from day to day is very

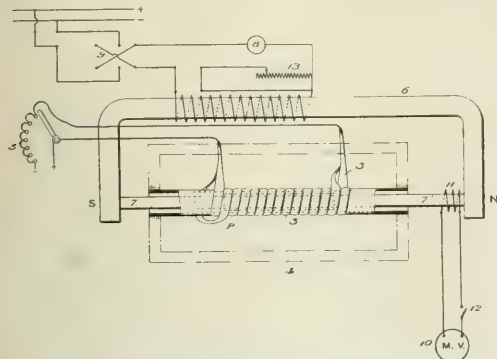


FIG. 1—MAGNETIC CRITICAL POINT APPARATUS

desirable. In operating these furnaces in natural draft, difficulty is experienced in obtaining uniform heat due to changing atmospheric conditions. In order to obviate this difficulty JOHN A. SWINDELL of Pittsburgh, Pa., proposes in a recent patent, to operate on a natural draft at the beginning, and when the iron reaches its full melted condition, the ash pit doors are closed and forced draft put on. In this manner uniform heats are claimed to result. To prevent the formation of clinker at the grate, and also to relieve the cutting action on the furnace lining, due to the forced draft, steam may be introduced underneath the grate. (1,188,111, June 20, 1916.)

Production of Ferromanganese.—An electric furnace process for producing ferromanganese from waste clinker or cinder from zinc furnaces, and also recovering the zinc, is patented by HARRY SCHAGRIN of South Bethlehem, Pa. The furnace in which the process may be carried out is shown in Figs. 2 and 3.

The waste clinker or cinder from zinc smelters using franklinite or willemite ores, containing 15 to 22 per cent MnO, 28 to 56 per cent FeO, 20 to 30 per cent SiO₂, 8 per cent C, 6 per cent Al₂O₃, 10 per cent CaO, and about 4 to 5 per cent ZnO, is crushed to a suitable size, mixed with 25 per cent by weight of waste coal dust, and a quantity of limestone flux. The charge is placed in hopper 6, and fed by the screw conveyor to the furnace stack. When a sufficient amount of the charge has accumulated around the electrodes, the current is turned on and the temperature brought up to 1500 deg. C. while charging continues. The charge melts, forming the molten pool 20, when the iron and manganese settle down and the slag rises to the top.

The zinc in the charge is volatilized and is drawn off by suction through openings 21 to chamber 23, where it settles. Any zinc passing up beyond the pipes is caught and condensed by the downcoming charge, which is cool at the top and returned to the fusion zone. A reducing atmosphere is maintained in the furnace, and the temperature is not allowed to rise much over 1500 deg. C. It is claimed that the process avoids serious loss of manganese, and works well on low manganese material. (1,190,679, July 11, 1916.)

Production of Silicospiegel.—A modification of the above process as adapted to the production of silicospiegel is described in another patent of HARRY SCHAGRIN. In this case the charge is substantially the same, but the temperature is raised to 1800 to 2000 deg. C. The zinc is volatilized and collected as before, and silicon is reduced along with the iron and manganese, producing on the hearth an alloy containing from 10 to 15 per cent silicon, 10 to 20 per cent manganese, 15 per cent aluminium, and 60 to 70 per cent iron. (1,190,678, July 11, 1916.)

Electrochemistry

Manufacture of Aluminous Abrasives.—A process of making aluminous abrasives which aims to avoid the intermittent running of the furnace and to make the process more continuous is patented by THOMAS B. ALLEN, of Toronto, Can. The patent is assigned to the

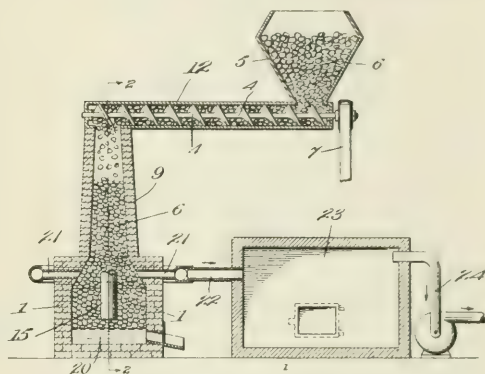


FIG. 2—END VIEW OF FERROMANGANESE FURNACE

General Abrasive Company, of Niagara Falls, N. Y. The process consists in heating a mixture of bauxite and coke in an electric furnace, and tapping separately the resulting abrasive and by-product such as ferro-silicon. The by-product is formed as a result of the reduction of iron, silicon and titanium oxides contained in the bauxite. In Fig. 4 is shown a furnace in which the process may be carried on. A is a brick foundation, B is a lining made of a mixture of coke and tar, F is a tap hole for abrasive, G is a tap hole for ferro-silicon. Carbon electrodes are shown at C. Polyphase current

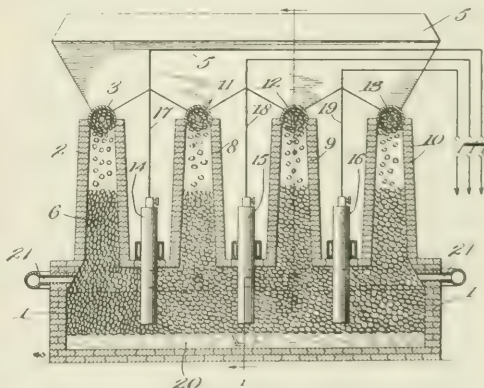


FIG. 3—LONGITUDINAL VIEW OF FERROMANGANESE FURNACE

is preferably used with the necessary number of electrodes.

The charge is made up of 100 parts by weight of calcined bauxite, to nine parts of coke. These are both ground fine and intimately mixed. The mixture is charged and heated in the furnace until 7000 to 8000 lb. is melted and reduction has taken place, which can be judged by the appearance of the molten mass. As soon as reduction is complete and sufficient time elapsed for the settling of the ferrosilicon, the abrasive in molten form is removed by means of the tap hole *F* and

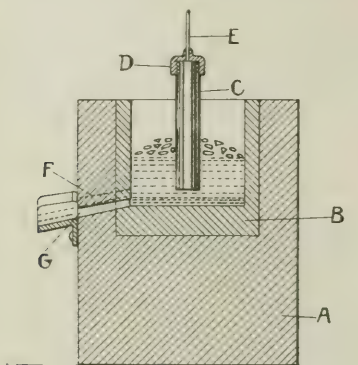


FIG. 4—ALUMINOUS ABRASIVES FURNACE

cast into ingots of a size determined by the quality desired in the abrasive produced. After its removal the ferrosilicon is tapped out by means of the tap hole *G*. The process is then repeated before the furnace cools. The abrasive after cooling is crushed up into suitably sized grains and is then in shape to be used for abrasive purposes. (1,187,225 June 13, 1916.)

Electric Furnace.—An electric furnace which is rotatable horizontally about a vertical axis and which may also be tilted for pouring the charge is patented by PETER EYERMANN, of Witkowitz, Austria-Hungary. A sectional view of the furnace is shown in Fig. 5. The crucible 1, is made of any suitable refractory material and is supported on a frame or cradle 5, by means of annular ball bearings 2, and an upright pivoted bearing 24 at the axis of rotation of the crucible. The crucible is rotated by means of a worm 10, which is driven by an electric motor. The frame and crucible may be tipped for pouring by rocking on the base 27 by means of hydraulic mechanism, as shown at 23. The electrodes 8, extend through the roof as shown. They may vary in number and are so arranged on the roof that the center line of the group, represented by the line 19-19, will be eccentric with regard to the axis of rotation of the crucible, represented by the line 3-3, so that when the crucible is rotated on its axis, each of the electrodes describes a different path, thus subjecting the various parts of the metal to the action of the current. This feature is claimed to necessitate only a small number of electrodes. (1,189,356, July 4, 1916.)

Electrolytic Cell for Magnesium.—A method of production of magnesium or other alkali metals by electrolysis so that the metal collects in considerable amounts is described in a patent of CHRISTIAN DANTSIGEN of Scotia, N. Y., which is assigned to the General Electric Company. The feature of the cell is a cathode which will alloy slowly with the magnesium. The cell is made of magnesite brick, and a fused electrolyte of potassium chloride and magnesium chloride in molecular proportions, to which may be added 2 or 3 per cent of calcium

fluoride is used. Anodes are of carbon, and cathodes are of sherardized iron, copper-coated iron or tin-coated iron. Any of these will alloy slowly with the magnesium and produce large masses of magnesium at the cathode. The molten metal wets the surface of the zinc-iron alloy, and hence remains attached. An advantage is gained if several cathodes are used in one cell as a more effectual collection of the magnesium takes place. The

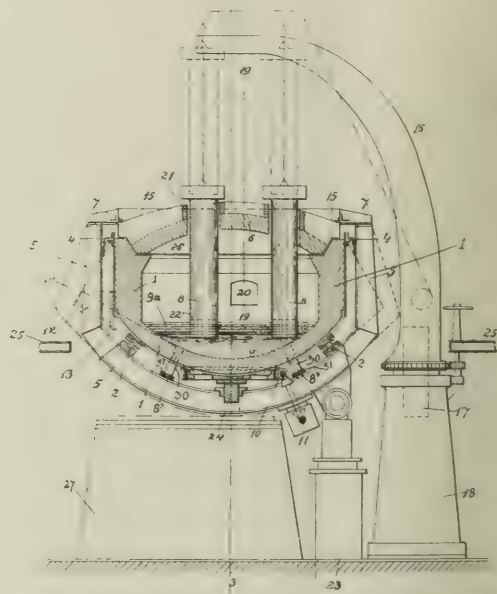


FIG. 5—REVOLVING ELECTRIC FURNACE

amount of zinc which will alloy with the magnesium is small, and may be neglected for any of the known commercial uses of metallic magnesium. (1,190,122, July 4, 1916.)

Separation of Neon from Other Gases of the Atmosphere.—The production of liquid air in a large scale has made possible the production of large amounts of nitrogen and also made possible the production on a commercial scale of the other gases contained in the atmosphere, such as argon, helium and neon. A process of separating neon from the other gases mixed with it, more particularly helium, is patented by GEORGES CLAUDE of Boulogne-Sur-Seine, France. A tube such as shown in Fig. 6 contains carbon electrodes *g*, and connections *m* and *n* for a vacuum pump and impure

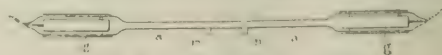


FIG. 6—NEON PURIFYING TUBE

neon respectively. The tube is exhausted to a pressure varying between 0 and 10 mm. of mercury and the gases admitted. An electric discharge is then passed through and the foreign gases are absorbed, leaving the neon in a substantially pure state. The minimum surface area is 1.5 sq. dcm. per ampere. A comparatively large surface area is desirable since the neon is absorbed so much more slowly than the other gases.

The process is particularly applicable when the puri-

fied neon is to be used in a rarified state in the enclosure in which it has been obtained. The neon is extremely permeable to electric discharge and has found application in detectors of Hertzian waves, luminous tubes, etc. The process is of especial interest as it makes it possible to separate neon from helium effectively. (1,191,495, July 18, 1916.)

Alloys

Heat-Resisting Alloy.—A patent has been granted to JOHN C. HENDERSON of Washington, D. C., and assigned by him to the Driver-Harris Wire Company of Harrison, N. J., on the manufacture of cast articles of nichrome. A description of experimental work done on these articles was given in this journal, Vol. XV, page 159, Aug. 1, 1916. The articles are intended to withstand temperatures of from 1000 deg. Fahr. upwards without suffering corrosion, pitting or oxidation. The composition is nickel 60 per cent, iron 26 per cent, chromium 12 per cent, and manganese $1\frac{1}{2}$ per cent. If substantially carbon free (less than 0.4) the alloy can be machined, rolled or forged. The alloy requires a high melting heat, but when once sufficiently melted can be cast in the ordinary manner. Some of the articles mentioned are molds for die casting, valves and valve seats for internal combustion engines, crucibles, outer casings for crucibles, linings for molds and crucibles, annealing boxes, case-hardening or carburizing boxes, and other apparatus. The manganese is not essential but is merely the remnant of manganese from the raw materials used.

When subjected to oxidizing temperatures, a slight film of oxide forms on the surface of the article, which is strong and durable, and resistant to sulphuric and hydrochloric acids and alkalis. This oxide is non-flaking and adheres strongly to the mass. (1,190,652, July 11, 1916.)

Measuring Water with a Weir Meter*

BY E. G. BAILEY

A V-notch or rectangular weir offers many advantages for measuring water at or near atmospheric pressure. The flow curve is such that greater accuracy is readily obtained over a wider range in rate of flow than with the Venturi or Pitot tubes. From an accurate knowledge of the flow curve for any given shape of weir notch, it is possible to use the level of the water above the notch to continuously record the rate of flow and integrate it so that the total may be read from time to time. The nature of the flow curve of a V-notch weir as shown in Fig. 1 brings out clearly the point that at low rates of flow there is proportionately a great deal of head, or power, to operate any float-driven mechanism. The converse is true at the higher heads where a very slight change in head means a much greater change in rate of flow.

The accuracy of the V-notch has never been questioned but the points of primary importance are to accurately measure the head and to be sure that this measurement is referred back to the true zero of the notch. These points are difficult enough when using hook gages with micrometer screws in a hydraulic engineering laboratory, and even more so when continuous recording and integrating mechanism is used to measure the rate and total flow.

The zero level can be readily obtained in test or calibration work if a permanent hook gage point is

riveted to the weir plate as shown in Fig. 2. This can be accurately located in the machine shop and is absolutely correct by construction.

It is always preferable to have chart records on uniformly graduated charts and in order to use the best form of integrating devices it is essential to have a motion directly proportional to the rate of flow instead of proportional to the head.

There are many ways in which this may be accomplished with more or less accuracy, but the motor with the simplest mechanical construction always gives the best satisfaction and continued accuracy over a long period of time.

The mechanism used in this apparatus operates on the buoyancy principle, as shown in Fig. 2. The displacing members are exactly balanced and weighted so that they are heavier than water and do not act as floats. If they were of equal and uniform cross sec-

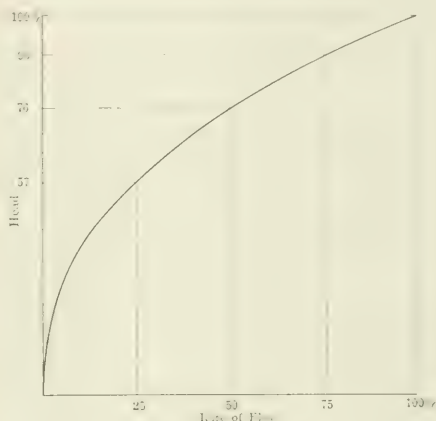


FIG. 1—FLOW CURVE

tional area the rising of the water level would produce no motion but would merely cause them to become lighter on their knife edge supports by an amount equal to the weight of water displaced. But by properly shaping these spun copper displacing members a powerful motion that is directly proportional to the actual flow is obtained directly from the main shaft itself.

Thus when the rate of flow is 25 per cent of the maximum capacity of the meter, the motion given to the pen is 25 per cent of the total motion. At this point the level of the water has increased to 57 per cent of the total range in head.

The motion of the displacing members, and also the recorder pen, has not been relatively as much as the change in head, but it is directly proportional to the rate of flow. The total motion of each displacing member is, of course, less than the total change in water level. The maximum head is 10 in. and the corresponding motion of the displacing member is 4 in.

The characteristic of the flow curve of a V-notch weir is the basis for the often repeated argument of its great accuracy at the low rates of flow. But upon closer analysis it is found that this argument is a boomerang when considered in relation to the higher rates of flow, unless the recording mechanism is properly designed. An error of a few hundredths of an inch in a hook gage or straight float that rises directly with the water level may mean as much as 5 per cent error in the flow of reading at the higher rates.

The design of this weir meter entirely obviates the

*A paper read before the June meeting of the Ohio Society of Mechanical, Electrical and Steam Engineers at Cleveland. Slightly abstracted. The author is president of the Bailey Meter Company of Boston, Mass.

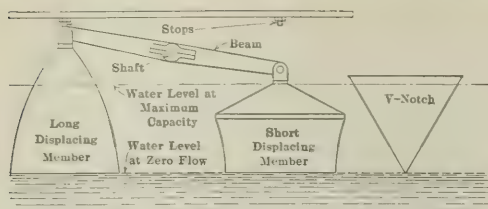


FIG. 2—PRINCIPLE OF METER

possibility of such an error, for the relative position of the two displacing members is made right by construction, and no changes can possibly take place to alter it. The pen and integrator can be set to their true zero so long as the water level is within $\frac{1}{2}$ in. of the bottom of the notch, and there will be no error at the higher readings.

The working arrangement of these displacing members is shown in Fig. 3. The beam which carries the displacing members on monel metal knife edges is fastened to a shaft supported on monel metal knife edges. The end of this shaft extends through a pressure-tight bearing and carries the recorder pen and integrator driving directly on its outer end.

The question of integrating the flow of any fluid brings up many problems that have been more or less troublesome on other types of meters as well as of the weir type. Principal among these are imperfect drive due to vibration and the wearing smooth of the driving disc.

A detail of the integrator which has been found very satisfactory is as follows: In this the disc is driven by the same clock movement which drives a chart; the disc making two revolutions per hour. The counter is suspended from a knife edge bearing on the clock frame and is moved across the disc by an arm extending from the main shaft which also carries the recorder pen. The follower wheel which is in contact with the clock-driven disc bears in the center for zero flow and is moved outward to a radius of $3\frac{1}{2}$ in. at maximum rate of flow. This follower wheel is provided with a large number of rollers on its circumference which practi-

cally eliminate friction as it is moved across the disc and also prevents wearing the disc smooth, so that continued accuracy is obtained over an indefinite period of time without attention. The axis of the follower wheel is mounted slightly inclined from the perpendicular to the clock-driven disc so that the follower wheel bears against its projecting edge instead of its extreme circumference. This gives a greater arc of contact and eliminates error due to slip. This wheel is held against the disc by a flat spring and a small pressure of this part prevents any error due to vibration. This arrangement also simplifies the construction so that spur gears are used to drive the countertrain.

A record of one of these meters when receiving returns from one system which had an electric motor-driven pump that is intermittent in its action due to a float control showed interesting results. The meter calibration test Jan. 28th was made on this meter on this day when the rate of flow was varying from less than 2 per cent to over 90 per cent of the meter's rated capacity, every 8 to 10 minutes. The last calibration test which was made was at a very low rate, it being only 1240 lb. per hour, which is $2\frac{1}{2}$ per cent of the meter capacity. One of these meters agreed within 2.7 per cent of actual weight on the 15-hour tests, and while the other meter shows a larger percentage error yet this is equivalent to only 1 per cent at 35 per cent capacity, and this error would be produced if the follower wheel was only one hundredth of an inch out of its true adjustment, which was found to be the case at the end of this calibration.

A record of the water temperature is also made on the same chart with the rate of flow. This is accomplished by means of a recording thermometer having its bulb located in the flowing water. If temperature record is not desired the full pen motion on a 12-in. chart may be had.

New Design of Automatically Controlled Low-Pressure Valve

The adjoining illustration shows a low-pressure steam valve, electrically operated, requiring 0.5 amp. and 110 volt direct current, which has been developed by the Geissinger Regulator Co., 203 Greenwich Street, New York City. It is used in connection with the automatic "equitherm" controller of temperatures, and has proved to be an economizer of waste steam in large plants. It is used on apparatus requiring low-pressure steam.

The valve opens and shuts under the guidance of an electric thermostat, the lead *C* shown in the illustration connecting the thermostat with the magnet head *B*. The fall of temperature past the critical degree closes the thermostatic circuit, energizes the relay coil in the control cabinet, and closes the valve coil circuit contained in the magnet head *B*.

This attracts the armature of the pilot valve stem in the pilot valve *E*, which on lifting allows high-pressure steam from line *D* to pass through the pilot valve and under the piston contained within the high-pressure cylinder *G*.

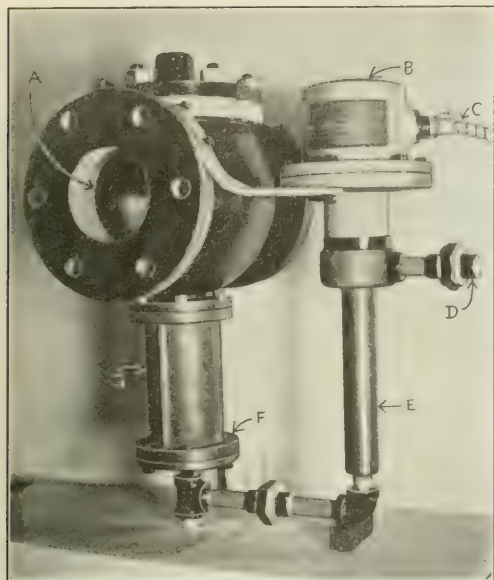
A rod connects the piston and the bottom of the low-pressure valve disk, so that when the piston rises the low-pressure valve disk is lifted off its seat, against the low-pressure steam, which is on top of the valve disk.

The low-pressure inlet on top of the valve disk is shown at *A*.

The valve works on the principle of a check valve. It takes pressure and gravity to close it. The high-pressure steam is used as an agent to open the low-pressure valve automatically. There is no waste of the high pressure, as it acts as a heating unit with the



FIG. 3—WORKING ARRANGEMENT OF METER



AUTOMATIC LOW PRESSURE VALVE

low-pressure steam. This type of low-pressure valve makes it possible to utilize exhaust steam. When the supply of low-pressure steam is not enough at a certain time the high-pressure will take care of the difference when necessary. Under ordinary conditions control can be maintained within 1 to 2 deg. Fahr.

Enlarging Photographs Without the Use of a Lens

An interesting American Physical Society paper by Alfred J. Lotka of the General Chemical Company of New York City, is published in the June, 1915, issue of *Physical Review*, describing a new method for enlarging photographs without the use of a lens. This method was developed by the author as the result of an observation of a peculiar distortion presented by the appearance of certain moving objects.

The method consists in moving the negative to be

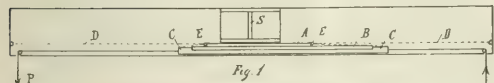


FIG. 1—DIAGRAM OF APPARATUS

enlarged past a narrow slit source of light, and at the same time moving a sensitive plate under the negative at a speed equal to some constant multiple n of the speed of the negative.

On development of the sensitive plate a positive transparency is obtained, in which all lines of the original negative which were parallel to the slit during the exposure are unaltered, while all lines at right angles to the slit are magnified in the ratio $n : 1$.

This positive is subsequently subjected to a repetition of the process practised on the original negative, but with the motion now at right angles to the lines drawn out n -fold in the first operation. The result of the second operation is a negative geometrically similar to the original, but with the linear dimensions enlarged n times, or the area n^2 , as will be easily understood.

The apparatus employed for carrying out the process has been constructed on exceedingly simple lines, with the use of material readily obtainable on the market. The slit is made with two strips of brass picked from the stock of a wholesale hardware store and having received no other treatment than a cleansing with a brass polish.

The ratio n of the velocities in the apparatus so constructed is 2, and is secured by the simple expedient shown diagrammatically in Fig. 1. In this drawing the original negative is represented at A, the sensitive plate at B, and the slit at S. The carrier C, on which the plate B rests, has attached to it at each end a silk thread D, which passes through an eye E, attached (with gummed paper) to the glass plate of the negative (when a celluloid film is used, such film may be attached with gummed tape to a glass plate). The further end of the silk cord D is attached to the end block of the box containing the negative and plate during exposure. The carrier C slides on the bottom of the box, between guides adjusted to fit the sides of the plate.

It will readily be seen that, in accordance with the principle of the single movable pulley, the velocity of the sensitive plate is always double that of the negative.

Any means, such as a hand-pull at P, may be employed to impart uniform motion to the negative. A cylinder containing water through which a fairly snug-fitting perforated piston is drawn makes a good dash-pot to regulate the motion. This and a still simpler and exceedingly compact device for this purpose is a subject of a pending patent application.

The adjustment of the lamp vertically above and in the plane of the slit is effected by looking down at the lamp and its reflection in the glass covering the slit. When the filament, its image and the line of the slit coincide in the line of sight, the filament is in the plane of the slit. It was found that with a slit $6\frac{1}{2}$ in. long good results were obtained with a filament of six or seven coils placed about 1 ft. from the slit.

Among the advantages which the new method presents is uniformity of illumination over the entire field; geometric similarity to the original of the image produced, i.e. absence of distortion such as spherical aberration introduces; compactness and simplicity of apparatus, replacement of lens by a simple slit and hence low cost of the apparatus.

The process necessitates two successive exposures, but this is true also of the ordinary method when a negative is to be prepared from a negative.

The example shown in the accompanying half-tone illustration gives an idea of the working of the process, though it does not represent the best that can be done in the way of definition.

The limiting separation which the apparatus will effect can be figured as follows:

Consider a point right on the edge of the negative. This will begin to be reproduced on the sensitive plate as soon as the negative and plate are in the position

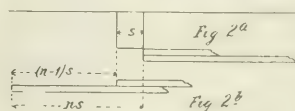


FIG. 2—DIAGRAM OF APPARATUS

shown in Fig. 2a. (The slit is here shown on a greatly enlarged scale.) The same point will continue to be reproduced until negative and sensitive plate are in the position shown in Fig. 2b. It will therefore be drawn out into a line of length $ns - s = (n-1)s$.

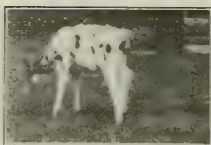


FIG. 3 — HALF-TONE COPY OF ORIGINAL PHOTOGRAPH



FIG. 4—COPY OF DISTORTED POSITIVE TRANSPARENCY OBTAINED IN FIRST STEP OF PROCESS



FIG. 5—COPY OF ENLARGEMENT OBTAINED IN SECOND STEP

Now consider two points, a distance d apart in the negative. In the copy they will appear as two lines $(n-1)s$ long and with their centers nd apart. These two lines will just coincide at their ends when

$$nd = (n-1)s,$$

$$d = \frac{n-1}{n}s.$$

This distance

$$d = \frac{n-1}{n}s.$$

between two points on the original negative represents the limit of separation: Two points a distance greater than d apart will be separated, two points nearer together than d will not be separated.

For $n = 2$ as in the apparatus constructed, we have $d = \frac{1}{2}s$.

Thus, for example, a comparatively coarse slit 1/100 in. wide, will still separate points just a little over 1/200 in. apart.

The process and apparatus here described are protected by U. S. Pat. 1,176,384 of March 21, 1916, issued to Alfred J. Lotka.

Personal

Mr. Walter A. Barrows, Jr., of Brainerd, Minn., who for some years has been engaged in iron mining in Minnesota, has been elected president and general manager of the Thomas Iron Co. of Easton, Pa. He succeeds Ralph H. Sweetser, who recently resigned.

Mr. Samuel H. Dolbear, consulting mining engineer, of San Francisco, was in New York a few days during the middle of August. He went from New York to Washington and from there back to San Francisco.

Mr. R. H. Fash, chief chemist of the Chickasha Cotton Oil Co., has been appointed active vice-president of the Fort Worth Laboratories, Fort Worth, Tex.

Mr. E. T. Foote, formerly of the New York office of the Cutler-Hammer Mfg. Co., and at one time in the engineering department at its Milwaukee factory, has recently been put in charge of the Boston office, located in the Columbian Life Building. Mr. Foote's experience in the engineering department and sales engineering work in New York fit him admirably for his new position.

Dr. Milton Hersey of Milton Hersey Co., Ltd., Montreal, Canada, has returned from a trip through the Northwest, where he has been investigating the resources and industrial possibilities of the country for the Canadian Northern and Grand Trunk Pacific Railways. His company has recently opened an office in New York City at 198 Broadway.

Mr. M. H. Kuryla is in charge of erection of the new electrolytic zinc plant of the Judge Mining & Smelting Co., Park City, Utah. In our issue of Aug. 1 it was erroneously stated that Mr. M. H. Atwater was in charge.

Mr. S. G. Lilja, formerly with the Helsenborg Copper Works, Helsenborg, Sweden, is now engineer with Hamilton & Hansell, Stockholm. He has recently been in this country looking over the electric furnace field.

Mr. N. Petinot, formerly with the Titanium Alloy Mfg. Co. of Niagara Falls, N. Y., has opened an office at 200 Fifth Avenue, New York, as electrometallurgical engineer specializing in ferroalloys.

Mr. Wm. Printz, formerly assistant sales manager of the Brown Instrument Co., Philadelphia, Pa., will be in charge of the new Detroit office of the company opened on Sept. 1. The office will be located at 612 and 613 Chamber of Commerce Building.

Prof. M. C. Whitaker, professor of chemical engineering at Columbia University, has been granted leave of absence for the first term of the academic year 1916-1917.

Industrial Notes

The Thwing Instrument Co., Philadelphia Pa., has issued general catalog No. 8, describing Thwing electrical recording pyrometers. Three types of pyrometers are described, viz.: thermoelectric, radiation, and resistance.

The Foxboro Co., Foxboro, Mass., has issued Bulletin No. 104, describing Foxboro indicating and recording thermometers. Four classes of instruments are described, ranging in temperature scales from 60 deg. F. to 900 deg. F.

The Elyria Enameled Products Company, Elyria, Ohio, has erected a new chemical laboratory equipped to carry on a full line of analytical and research work. The company feels that the addition of facilities afforded will enable it to be of larger service to its friends.

Petroleum Output in 1915.—The petroleum output in the United States in 1915 broke all previous records with a production of 281,104,104 barrels. This is nearly a 6 per cent increase over 1914. The average price received at the well was 64 cents per barrel. Oklahoma led in production, with nearly 98,000,000 barrels. California was second with about 86,600,000 barrels. The next largest producer was Texas, with about 25,000,000 barrels.

New Chemical Plant in St. Louis.—The Mineral Refining & Chemical Co., a company formed last January, is constructing a large plant at St. Louis, Mo., for the manufacture of a substitute for white lead and zinc white in paint manufacture. The daily capacity will be 50 tons. Eight wood and stone buildings will comprise the plant. The construction work is being done by the Fruin-Colnon Contracting Co. Jose Harimon, president of the Spanish Bank of Commerce and the Spanish Bank of Cuba, at Havana, is president of the new company.

Pyrometers.—The Brown Instrument Company, Philadelphia, Pa., are now manufacturing indicating and recording pyrometers for ranges from 400 deg. F. to 3000 deg. F. (1600 deg. C.), and also recording thermometers for low temperatures. These will be on exhibit at the coming Exposition of Chemical Industries in New York in September.

C. O. Bartlett & Snow Co., Cleveland, Ohio, has received the contract for equipping the plant of the Cosmopolitan By-Products Co., New York City, with the Cobwell system of garbage reduction.

New Refiner for Paper and Pulp Industry.—The Manitowoc Engineering Works, Manitowoc, Wis., has issued a circular describing the Howard refiner, which has found successful application in paper, pulp, and other industries.

The Cutler-Hammer Mfg. Co., Milwaukee, Wis., has leased new and larger New York City offices on the nineteenth floor of the Hudson Terminal, 50 Church Street, providing nearly double the space previously occupied. Mr. W. C. Stevens is manager of this office.

Aparatos Destiladores de Agua.—Messrs. Eimer and Amend, New York City, have issued a pamphlet in Spanish describing the Barnstead & Stokes water-distilling apparatus.

Cost System for Manufacturers.—The Federal Trade Commission, Washington, D. C., has issued a pamphlet entitled "Fundamentals of a Cost System for Manufacturers." This pamphlet shows briefly the importance of accurate manufacturing costs and the fundamental principles underlying them, and should prove of value to a great many manufacturers who have not gone into detail in the subject of costs.

The Denver Fire Clay Company, Denver, Colo., has issued an attractive booklet, designated Catalog D, describing Case metallurgical furnaces for melting, refining, assaying, tempering, annealing and enameling. Furnaces are described operating on fuel oil, gasoline, gas, coal, coke and wood.

Multiblade Fans.—The Clarage Fan Company, Kalamazoo, Mich., has issued catalog No. 5, describing the Clarage-Kalamazoo multiblade fan for heating or ventilating installations. The catalog includes capacity and dimension tables for facility in determining what size to use.

Trust Laws and Unfair Competition.—The U. S. Commissioner of Corporations, Joseph E. Davies, has just issued a long report on "Trust Laws and Unfair Competition." This report grew out of the preparation of a large amount of material in connection with the antitrust legislation enacted recently, and it was decided by the Secretary of Commerce and the Commissioner of Corporations that the material was of such a character that it ought to be placed in permanent form to be available for publicists, economists, business men and statesmen for reference. This treatise designs to cover in compact form the laws of the various countries of the world pertaining to the prevention or regulation of monopoly by government, and

the prevention of unfair practices of competition. The last chapter is on the activities of trade associations and their relation to laws concerning competition in the United States.

Determination of Aluminium.—The Bureau of Standards has published the results of research work done on the determination of aluminum, as Scientific Paper No. 286. From observations made with a hydrogen electrode and with suitable indicators, the conditions for the quantitative precipitation of aluminium hydroxide by ammonium hydroxide were determined. In practice, the completion of precipitation may be defined by means of methyl red or rosolic acid. The effect of various factors upon the precipitation, washing and ignition of the precipitate was determined. The procedure for obtaining accurate results is also described.

Vanadium Company Sold.—The American Vanadium Company of Pittsburgh, a \$700,000 corporation, formed in 1906 to mine and sell vanadium, has been purchased by a group of Eastern capitalists, and a new company formed to take over and operate the old company. The new company will have a capitalization of \$13,500,000, and will operate under the old name. James J. Flannery of Pittsburgh, president of the old company, will become chairman of the board, and J. J. Replogle, now vice-president and general manager of sales, will be president. The American Vanadium Company controls the largest part of the known vanadium deposits of the world, its use in high-speed steel having given rise to a considerable production.

Digest of Electrochemical U. S. Patents

PRIOR TO 1903

Arranged according to subject-matter and in chronological order.

Compiled by Byrnes, Townsend & Brickenstein, Patent Lawyers, National Union Building, Washington, D. C.

Aqueous Bath, Cathodes Metallizing

211,610, Jan. 21, 1879, Napoleon W. Williames of Philadelphia, Pa., assignor to himself and Wm. W. Keys, of same place.

Relates to bronzing iron railings, etc., for ornamental iron work, enclosures, etc. The iron is first coated with a paraffin varnish, and this coated with plumbago; it is then immersed in a copper-plating solution, such as the sulfate or chlorid, and copper deposited thereon.

215,034, May 6, 1879, Isaac Adams, Jr., of Boston, Mass.

Relates to covering metals with vulcanized rubber. The metal article, if other than copper, is first coated with a thin film of copper; if the metal article is copper, then a thin film of other metal is first applied, such as tin, nickel, iron, etc., and upon this is applied a thin film of copper. Instead of a film of copper, one of silver may be used. Copper and silver have a tendency to unite with the sulfur in the vulcanized rubber, and it is this property which makes these metals useful for this purpose. After the copper film is formed, the rubber is applied and vulcanized to the copper in a mold, or under pressure.

226,873, April 27, 1880, Irwin M. O'Donel of Pittsburgh, Pa., assignor of one-half of his right to William J. Fullerton of same place.

Relates to the formation of molds having non-oxidizable surfaces, for the manufacture of molded glass, etc. A pattern of the article to be molded is made of clay, wax, or other suitable substance, and a coating of

graphite applied to the surface to be imitated. The pattern is then immersed in a solution of platinum, cobalt, or other non-oxidizable metal or alloy, and a deposit thereof produced on the graphite. The mold is then removed to another vat containing a solution of a cheaper metal, and a deposit of sufficient thickness applied to strengthen it. The deposited shell is then removed and placed in a suitable mold, and a sufficient amount of iron is then cast to or upon it to strengthen and preserve it. It is then finished on its edges, etc., and is ready for use. Metal molds which need to be repaired may be electroplated with a non-oxidizable metal to reduce them to the desired size. The alloy preferred is composed either of iridium or platinum and copper, in the proportion of about one-half each.

227,370, May 11, 1880, Albon Man of Brooklyn, N. Y.

Relates to uniting or framing pieces of glass, china, porcelain, crockery, stoneware, etc. The materials may be first fire-gilded, silvered, or platinized on the parts to be metalized; or the materials may have a coating of lead, zinc, or other metal, or oxids of metals or their salts, applied in a hot state, to the surfaces to be coated, to render it conductive. Or an amalgam of mercury and tin or other metal may be applied; or the surfaces silvered by the precipitation of metallic silver by the mirror silvering process. The coated pieces are then assembled and electroplated, thereby uniting or joining into a unitary structure. Or the several separate pieces may be copper-plated, and then soldered together. The method is said to be useful in securing several glass or porcelain pieces together, or to metal, such as the parts of philosophical apparatus, incandescent lamps, ornaments, etc.

240,615, April 26, 1881, Frederick S. Shirley of New Bedford, Mass.

Relates to the manufacture of molds for making pressed glass, etc. A suitable model of the article to be made with the desired ornamentation is coated with graphite and electroplated with a heavy deposit of copper or other suitable metal or alloy. The deposit is then cut in suitable sections to make a sectional mold, studs or lugs being first secured to the backs of the deposited metal to serve as anchors in reinforcing metal later cast against the backs of the mold sections.

299,055, May 20, 1884, Thomas W. Collins of New York, N. Y., assignor of one-half to Alfred H. Smith & Co., of same place.

Relates to securing diamonds in the edges of cutting tools, by depositing copper in the recess in the tool in which the diamond is placed. The diamond is first coated with copper as follows: It is dipped in a solution of phosphorus in bisulfid of carbon, then dried in the atmosphere. It is then dipped in silver nitrate solution until it becomes black. It is then washed, and if further metallic coat is desired, it may be dipped in chlorid of gold solution. It is then copper-plated. Instead of the above, after receiving the phosphorus coating, the diamond is placed in a solution of nitrate of mercury, and thereafter copper-plated. The copper-plated diamond is then placed in its dovetail shaped recess, and copper deposited in the space around the diamond to secure it in place. Other abrasives, such as corundum, emery, etc., may be secured in this manner.

321,711, July 7, 1885, William A. Gay of Newark, N. J.

Relates to the deposition of metal upon the surface of earthenware and the like, and consists in mixing finely-powdered clay, coke, etc., with sugar solution, tar, or other carbonaceous material, in the approximate proportions of 14 lb. of syrup or tar to about 45 to 50 lb. of the base or powder. The unsized baked earthenware

is covered at the desired places with the above mixture, and the whole submitted to pressure under moderate heat until the mass has firmly adhered to the article. The coated articles are then placed in crucibles, the spaces being filled with sand to exclude air, and the crucibles covered. They are then heated to a dull red heat for from one to two hours, and then allowed to cool. The carbonized surfaces are then cleaned free from sand, and are ready to receive the metallic deposit.

339,431, April 6, 1886, William J. Ladd of New York, N. Y.

Relates to an apparatus for connecting electrotype molds to conductors, and consists of a metallic hanger having mold-suspending hooks which are insulated. Contact with the metallic hanger and mold is made by an independently removable metallic contact piece capable of being secured to the hanger and which presses tightly against the conducting surface of the mold. The circuit may be broken at any time by removing the contact piece, without removing the mold from the electrolyte. The contact piece may be provided with a clock dial and adjustable hands to indicate the time the circuit should be broken, etc.

344,397, June 29, 1886, Robert F. Nenninger of Newark, N. J.

Relates to the manufacture of an electroplated fabric consisting of flexible material such as paper-pulp formed into sheets and dried. The fabric is then made waterproof by soaking in linseed oil, etc., and drying. The waterproof fabric is then stitched through at many points on both sides over each entire surface with bare copper wire, the wire extending for short lengths at each stitch on each surface of the fabric. One or both surfaces of the fabric are then coated with graphite, and the fabric immersed in the electrolyte. The metallic deposit anchors itself to the copper wires and spreads over the entire fabric. When completed, the plated fabric may be used for floor or wall covering, lining refrigerators, etc.

347,195, Aug. 10, 1886, David S. Plumb of Newark, N. J.

Relates to ornamenting glassware and the like, such as pitchers, etc., and consists in applying to the surface of the glass a continuous network or openwork of wax, glass cement, paint, etc., and producing the design in the wax, etc. A coating of bronze powder or graphite is now applied to the ornamented wax, and then electroplated with gold, silver, etc. The electroplate may be engraved if desired.

360,672, April 5, 1887, Otto S. Fertig of New York, N. Y.

Relates to hangers for suspending electrotype molds in an electrolyte, and refers to an earlier patent, number 151,892. The hanger is provided with two insulated metallic hooks by which the mold case is suspended, to prevent it from tilting sideways, and a metallic strip to make electric contact with the face of the mold.

362,927, May 17, 1887, Edward A. Blake of Chicago, Ill.

Relates to an apparatus for coating electrotype matrices with graphite. The matrix is placed upon a support in a suitable box having an outlet at the bottom, and through the top of which is directed a blast of air carrying graphite; the graphite is blown directly upon the matrix, into all the depressions, and provides an even and smooth coat of graphite over its entire surface. The excess of graphite is blown away and collects in the lower part of the box, from which it passes through the outlet therein and through a conduit up to a hopper which communicates with a blower supplying the blast of air to the matrix.

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Chemists in Combination

Two great chemical societies meet in New York during the week of September 25 to 30, when the chemical exposition takes place: the American Chemical and the American Electrochemical Societies. That the major organizations should meet at the same time is reasonable and wise, provided the idea is not carried too far. If the Chemical Engineers and the Society of Chemical Industry were also to foregather on the same days there might be a little overlapping.

The number of chemical bodies is a sign of activity, and they spur one another on to avoid the ruts and grooves of dullness. It is very easy for a learned society to grow obese and heavy, to save its offices as rewards for age and prosperity among the incumbents and to meet for the achievement of dignity and admiration. It is pleasant to sit, fat-headed, in big chairs, to pass resolutions in praise of science and the learned and distinguished body of savants who grace the occasion by their inspiring presence—and let it go at that. Most of us are capable of drifting into just such complacency—if nobody bothers us and everything comes our way and there isn't anybody else to do better. But when learned societies multiply—within reason, of course—there is less likelihood of the substitution of mutual admiration for work. One or two of them is bound to get busy, and with that the others also see that there is something to do.

We have in mind a certain society that had its origin and was located far away from here, with a name as imposing as that of the Sultan of Turkey and a charter as broad as that of the Manhattan Company, that for years and years did not contribute a single thing of real value to the public welfare. It had strong men and good men among its members, but the society did not do anything. It just lived along, blissfully content, assured of its social standing, and it served the purpose of its organization for public welfare by posing as the repository of transcendent wisdom. Suddenly a new condition arose and the service which it was supposed to render was called for. Then came trouble; pose the honorable body had; pose and poise, but it could not work; it was not set up to work. All of a sudden some technical men were drummed up apparently from nowhere at all, and the plain fellows, without honors and decorations, turned the trick and saved the day.

Now there is no present danger that such a situation will arise among our chemical societies. And yet, safety lies not so much in numbers as in the absence of vanity. Self-sufficiency is the killing thing. As soon as all the societies regard themselves as Perfect and Final Repositories of Knowledge, all will degenerate.

Indeed, as soon as any of them regards itself as having attained the pinnacle of desire, the feeling that it is accomplishing all that may be asked of it, so soon will its efficiency cease and the work have to be done by the others—as long as they last. Vanity and laziness are contagious maladies, and if one goes off there is the hazard that the others will follow. Fortunately the relations between the various chemical societies are full of friendliness and good will, and those in authority are men of catholic mind and disposition. Thus are petty jealousies avoided, out of which malice and anger grow. This is a matter of supreme importance, for anger kills the spirit of friendship and cripples progress. With all respect for every religious faith be it said, we have occasionally seen little towns with a dozen or more churches, and these seemed, somehow, to fail in the purposes of their organization, to fall short of establishing that brotherhood of man which leads to the Kingdom of God. A little investigation brought out the fact that each one was officially sure it was right and that all the others were wrong. It is the great good fortune of the scientific societies that they are free from these differences.

Professor Tyndall had a Scotch servant who served him faithfully to the end of his days. Every morning he rapped upon his door and said: "A-r-r-rise, Sir, a-r-r-rise! 'Tis seven o'clock an' ye have a g-r-r-reat wor-r-rk to do this day." Now science is so much greater than all the societies, its fields hither and yon are unploughed and uncultivated to so vast an extent, the battle against poverty and waste is so great and victory is so far away, that we have, all of us, a great work to do this day. And from the measure of the tasks which the chemical societies have set for their coming meetings, and the manner in which they are pulling together toward the distant goal, it would seem that they had called the old Scotchman's ghost and were listening to his message.

Made in America

There is a ring to "Made in America" that sounds pleasant in the ears of most of us—excepting importers. We like to read it and hear it, and are disposed to use the first person plural in reference to it, if it relates to that which succeeds. "We" have been leading the world in the iron and steel and copper and zinc and lead industries. "We" have been leading the world in electrochemical industries from the time that industrial Niagara Falls was founded. "We" have been leading in a number of industries of heavy chemicals, and if proof is needed that this leadership is not merely based on tonnage, but that this country can claim to have done its due share in technical improvements, the remarkable progress made in America in recent years in oil refining and cracking processes may be cited as just one example. But all these things are old stories, relating to industries in which this country always has had a decided natural positional advantage. But now since the European war has started, we have become independent of the foreigner even in a remarkable number of our industrial needs which formerly called for aid

from abroad and with respect to which the natural advantage of this country was not so clearly defined as to encourage home production on a large scale.

At the risk of boasting let us consider some of the industries that have either been born or have greatly developed since the war began and the European sources of supply have been shut off. Without attempting to make a complete list or even a systematically classified list, and mentioning them only as they come to mind, there are barium compounds and potash, the latter in insufficient quantity, but growing. Among the most remarkable strides are those made in the manufacture of glassware, the permanent substitution of soda glass for the potash product in electric lamps, and the development of high-grade ware for laboratory and technical uses that was heretofore generally considered hopeless in this country. The same may be said of laboratory porcelain ware. Instead of making "brands" of special steels according to "recipes,"—a condition that had not entirely gone out of vogue when the war broke out—the leading companies are beginning to regard the making of specified steels as a necessary and proper part of their business. More ferroalloys than ever are made in this country to meet urgent requirements. The manner in which a great calcium carbide plant at Niagara Falls was switched over to produce ferrosilicon under stress of need was a shining example of efficiency and good sense. The fireworks man and the automobile wallah, as well as the lecturer on chemistry, need worry no more about the imports of magnesium. They are making plenty of it at several places.

This country has taken the lead in the production of radium and is likely to keep it. Crucibles were made of foreign clays because there was nothing that would serve the purpose to be had here with the old methods—until the United States Bureau of Standards found how to do it. Now, prime quality earthenware and stoneware is made here for nearly every purpose. The ruthless, wasteful and consequently wicked destruction of organic products by beehive coke ovens is diminishing by leaps and bounds, wherefore we should cease to sorrow rather than to boast. Munition works have become leading industries in many places, and this is the only legitimate business that we hope to see curtailed by the circumstances of peace. For a time the daily press was insistent that these should all be turned into coal-tar color works immediately after the war, but we have not heard much of it lately. Possibly this was to be accomplished by the engagement of a chemist to come and say "presto," and thus turn the trick. We know of no better method.

Instruments of precision designed for scientific and technical work are coming upon the market from local makers, and they are good. The dyestuff industry is getting out of its muddle. Many of the larger dye and print works are making their own aniline, aniline salt, and aniline and sulphur colors. The old names like Schoellkopf, National Aniline, Heller and Merz, Hudson River, etc., are familiar, but consider the new ones: Beckers, Swiss Color, Federal Dyestuff, Bull's Ferry, Neidich Process, Butterworth Judson—to mention only

a few of the new producers. We have not heard of a full list of alizarine or fast cotton colors developed as yet, although indigo is produced here synthetically on a small scale. Dulcinea and Hermione may not have been able to match all of their shades of ribbon since the war broke out, but we have seen flesh-colored hosiery that seemed almost too successful in its tint. The demand why "we" do not make our dyestuffs here has lost its imperative quality; "we" do make them.

The list of synthetic products now made in America is growing daily. Among others are salol and the salicylates, sodium benzoate, benzaldehyde and photographic chemicals by the dozen. Pharmaceutical products are coming along; not all of them by any means, but a great many of the standard ones that were formerly imported and a very engaging list of new ones.

The old chemical pot is boiling.

Steel Tonnages "Made in America"

In the case of nearly all of the wonderful improvements that have been made in the manufacture of steel in the past thirty years, a precise statement of "who did it first" would be likely to provoke a controversy. The greatest single invention of them all, indeed, the pneumatic converter, furnished a subject of controversy for years. Bessemer's name was attached to it, but without Mushet's suggestion of the use of manganese it would not "work," while William Kelly of Pittsburgh, working in Kentucky, blew metal before Bessemer, but gave up his investigations because he feared that to develop the pneumatic converter would spoil the fairly lucrative business he already had.

When one thinks of "Made in America" in connection with iron and steel he is, however, on perfectly safe ground if he refers to tonnage. Whoever first suggested or practiced a certain improvement it is in the United States that the tonnages are made. In the production of pig iron here is a brief chart of the race. For many years the United States had made considerably more pig iron than Germany, but in 1875 Germany's metric tons slightly exceeded the gross tons of the United States. Then we have the following:

	United States, Gross Tons	Germany, Metric Tons	Great Britain, Gross Tons
1875	2,023,733	2,029,389	6,365,462
1890	United States passes Great Britain		
1890	9,202,703	4,658,451	7,904,214
1901	United States = Germany + Great Britain		
1901	15,878,354	7,880,088	7,928,647
1903	Germany passes Great Britain		
1903	18,009,252	10,107,901	8,935,063
1913	30,966,152	16 × Germany	3 × Great Britain

To continue the comparison for the period since the war started would not be illuminating as an index to the developments, but it may be noted that in 1915 the United States made as much pig iron as the rest of the world, and this year it will readily maintain the proportion.

While the United States has produced the large aggregate tonnages, it has also produced the large tonnages at individual works. It was in the American works that it was first decreed that the blast furnace should be the servant of the Bessemer converter, that if less silicon would shorten the blow the blast furnace

must make the lower silicon, and thus wonderful records were made by American Bessemer converters. If mills could roll more steel by being made heavier they were made heavier and were given more power.

The development of the Lake Superior ore region is one of many illustrations of how American engineers established new tonnage concepts. When the Panama Canal was being dug the *Canal Record* published statements of steam shovel performance of which the engineers were proud, but for years the Lake Superior region had been doing better with its shovels. Underground mines on the Mesabi range were largely abolished, it being shown that in some instances it would pay to remove 2 ft. of overburden to uncover 1 ft. of ore. The ore-carrying capacity of lake vessels has been doubled almost from decade to decade, until now there is a record of 13,800 gross tons of ore for a cargo, loaded and unloaded in a very few hours. When the ore had to be carried a thousand miles, by rail, water and rail to furnace, it was necessary that everything should be done at the lowest cost per ton.

The American steel industry has given the world some wonderful products. There is the all-steel freight car, and later the all-steel passenger, the latter adopted partly because if accidents cannot be avoided it is well to make them as comfortable as possible. The latest steel coal cars are designed for 120 net tons carrying capacity, the work of a dozen cars abroad. Scores of skeleton steel buildings have been erected in the United States with more than 10,000 tons of structural steel in the framework. The American steel industry furnishes steel for an annual output of 1,400,000 automobiles, vastly more than the output of all the rest of the world, and for this automobile industry it furnishes not only steel of high physical quality, but steel of high surface finish, for the automobile industry is the father of many common descriptions of steel to-day.

In the new industrial future of the United States the steel industry is likely to progress even more rapidly than in the past, but on somewhat different lines. It will take more interest in the refinements of fuel and other economies and in the manufacture of more by-products. In these directions it will be true to its traditions of doing everything on a large scale. The ideas may come from abroad, with or without a "thank you!" but they will be carried out with courage on the broadest lines.

The Bureau of Mines and American Radium Production

Instances of successful and profitable cooperation between the federal government and private enterprise, for the promotion of scientific and industrial research, are not so numerous as to be called readily to mind. In fact the principle has been questioned so frequently, both by individual and organized bodies of professional consultants, that a fairly well defined sentiment exists against the idea. The general proposition is open to debate, of course, and exceptions may be recognized, particularly when such exceptions have become demonstrated facts.

The work of the Bureau of Mines and the National Radium Institute offers a peculiarly happy instance of successful cooperation of the type mentioned; and as the term of that cooperation is drawing to a close we may review the whole experience and observe its effect on American radium production.

The terms of the agreement, in brief, were these: The National Radium Institute was organized by Dr. James Douglas, Dr. Howard A. Kelly and others, for the purpose of securing radium for therapeutic use. The underlying motive was philanthropic. A supply of ore was provided through an agreement with officers of the Crucible Steel Company, who owned carnotite-bearing land in southwest Colorado, and who leased this land to the Institute on a 15 per cent royalty basis, with an agreement to purchase the uranium and vanadium by-products. Then, in order to secure technical ability to operate the treatment plant, the Institute offered to furnish the Bureau with financial assistance to build and operate a mill for the treatment of 1000 tons of carnotite ore. The Bureau was to provide the services of certain of its staff for the technical control of the work. In addition to the opportunity thus afforded the Bureau to make a technological study of radium production, it was to receive any radium in excess of seven grams of anhydrous radium bromide produced from the 1000 tons of ore to be treated.

The results of three years' work now drawing to a close under this agreement may be recapitulated as follows: Approximately 1500 tons of ore and concentrate will have been treated when work ceases about the end of this calendar year. The National Radium Institute already has received its anticipated quantity of radium at a cost far below that indicated by the accepted market price. The Bureau of Mines also has obtained a part of its share and will ultimately receive a substantial quantity of the rare element for research purposes. Public benefits have accrued: An economical method of treatment has been developed for both ore and concentrate, and new radioactive methods of plant control have been devised. Some of these have been made public and all will be disclosed when the work is completed. The uranium-radium ratio has been proved to be in normal equilibrium in carnotite just as in pitchblende—an important fact for American producers. Valuable by-products of rare elements other than uranium and vanadium have been obtained for future study. Finally, as a sequel to the successful work with carnotite, an opportunity was recently offered to make a study of the concentration and treatment of low-grade pitchblende, which will add to our knowledge of radium production in this country. In this latter work the Colorado School of Mines was able to play a cooperative part through the use of its experimental mill.

Of course the personal element must not be overlooked in discovering reasons for the success of this venture. With men of less noble motives and narrower experience in the conduct of metallurgical enterprises, there would have been the chance of endless conflict and ultimate disaster. The times also were propitious with regard to public sentiment toward radium; while the un-

expected cessation of production abroad undoubtedly stimulated an interest in American production of radium from domestic ores. In spite of original opposition which engendered more or less bitter feeling, we seem to have here an example of successful co-operation that justifies the contentions of its supporters. Whether it can be duplicated depends on so many conditions that it can not be taken as criterion.

The Future of Steel Consumption

The marvelous increase in the production and consumption of steel has always been the subject of wondering comment, where will it end? The rule of pig iron production doubling every decade having been so often referred to, while doubt has been expressed in recent years whether the rule is still in force, a precise statistical comparison may prove of interest. The production in the ten years ended last year having been 257,714,701 gross tons, a tonnage of 256,000,000 tons may be taken for the decade, as that figure is susceptible of convenient bisection. We therefore show 256,000,000 with its successive bisections in the first column in the following table, and the actual production in the second column, the statistics for the earlier years not being precise, although amply accurate for the purpose.

Pig Iron Production, Gross Tons

Ten years ended	By rule	Actual
1915.....	256,000,000	257,714,701
1905.....	128,000,000	148,658,012
1895.....	64,000,000	76,061,628
1885.....	32,000,000	32,319,295
1875.....	16,000,000	13,559,866
1865.....	8,000,000	7,951,047
1855.....	4,000,000	6,400,000
1845.....	2,000,000	3,000,000
1835.....	1,000,000	1,600,000

When the figures are considered according to this scheme the rule of doubling is seen to have been followed with remarkable fidelity. The confusing fact that contiguous decades do not show the progress well, is eliminated quite largely by making the comparisons between the alternating decades. The comparison of the decade just ended with the preceding one or two decades would suggest that the rule has lately been losing its force, but if we go back four decades or six decades we find an almost absolute harmony. In dealing with inanimate objects physical and chemical experiments frequently show a much larger discrepancy, and yet are considered valid than is shown by this investigation of what man, in his varying circumstances and moved by various emotions, has done.

The most common explanation of the rapid increase in iron consumption is that of "new uses." In its barest form that is, of course, no explanation at all. Why the "new uses"? To furnish a real explanation there would have to be discoveries, and those discoveries would have had to come by chance, and not through the compelling force of circumstances, which is the usual one with discovery and invention. If circumstances brought forth the new uses, then what were the circumstances? We have had new uses which did not "pan out."

The one great influence in the increase in the use of iron is, after all, a very simple one, readily understood. It is no more nor less than the continued and

rapid increase in the ability of the people to buy, by reason of their increase in numbers and their greater wealth. That, really, has made the skyscraper as well as the automobile. It has made the large consumption of steel in freight cars and locomotives as well as in metal furniture and farm implements. It is the one principle that explains the rapid increase in the use of iron and the one index that one can consider and weigh as to its force in causing a further continued increase in future in the consumption of iron in its various forms.

Labor Conditions After the War

What will happen to all the new chemical works and their business after the war? It is hard to tell what European labor conditions will be. Fighting embitters men and many who are heroic in a dash against an enemy and will watch and wait through long days and nights for a chance to shoot, may, and again may not, be able to work steadily when the raging and the tumult is over. Generally speaking, however, aside from the injury to the mind caused by shock and passion and anger (as brought out by Dr. Crile), military training is good training and fits men for team work.

In this country labor conditions are not improving. There has been bluff, chicanery and the very limit of stupidity practiced by many employers and by many organizations of labor. We have said before and we say it again that the obligation of an employer does not cease when his pay clerk passes out the pay envelopes. General welfare of the men and their families; housing, sanitation, schools and good living conditions must be looked after. One of the severest indictments against an employer that has come under our observation was a crippled father, a mother approaching her end from medical neglect, and a large family of children, all illiterate and under-nourished, returning from the works of a pompous, self-satisfied captain of industry to their native home in northern Italy. There isn't any excuse for this sort of a crime, and it has been practised by sheer omission all too often.

On the other hand, we find an apparently increasing number of labor leaders and agitators who know no gospel save that of hate and destruction; and they have learned the art of leadership. A passion for organization has arisen among the ranks of labor, and once organized, its leading purpose seems to be to strike and to destroy. A fashion of thought which is growing among them is to take all grievances out of the public. If an employer will not grant this, that or 'tother, but more especially if he will not give over the functioning of his authority and judgment in the administration of work which he is paid to supervise, then "pound the public" is the slogan, until he gives in.

A few successful threats have started a season of bluffing extraordinary, and of a kind that has not been dared heretofore. Four railway unions want an eight-hour day, and so their representatives tell the Congress of the United States that unless they get it they will set about to starve the people. And they proudly show their entire conspiracy whereby they have actually

planned to inflict the ravages of hunger and disease upon the people of nearly the entire country unless their demand be granted. Then, instead of arresting the conspirators for planning such an heinous offense, as would have been done a dozen years ago, Congress obeys, and lets the men with the whip write the law! This is rank anarchy. Collective bargaining is just and right and proper, but collective blackmail and collective crime is no more to be endured than a single blackmailer or a single criminal. It is high time that we got this idea into our heads or the lash of the collective whip as a means of blackmail to gain power and advantage for self-organized groups of men, without reference to merit or justice, will destroy far more than property; it will destroy the liberties of all of us, rich and poor alike.

Now this is neither reasonable nor intelligent on the part of labor, nor is it a course to be expected, except as a result of a prevalent fashion or style of thought—and these are very contagious—or because men have been in charge of the affairs of corporations who may have had abundant executive ability but were lacking in character or were too timid to do right. But so long as labor goes by its abstract name and laborers are regarded as hands rather than as men, we cannot expect intelligence to abide in their organizations. The feeble-minded and incompetent are there because no other place has been found for them. There must be jobs for those who are below standard; jobs that pay a living wage and do not provide for the advancement available to entire men. Nobody wants feeble-minded workers in his establishment, but everybody that employs men in large numbers has them. He can't get rid of them; their fathers and brothers and sons will not let them go and the result is, now they are in the works, cutting down the pace and following the lead of every vicious notion that is presented to them, from breaking agreements to cracking skulls. Some place must be found for them and there is no change of turning them to profit; they are bound to be an expense in one way or another.

With the culls eliminated, a working staff can be organized that will beat the world, provided always there is the right measure and quality of brain tissue at the head. Some few concerns seem to be approaching this condition despite heavy labor costs and the reek of disorder in the air.

It behooves chemical industry to make its works attractive to those who earn their living there. Nothing helps more than an enthusiastic, loyal, well-paid working staff that believes in the company and is glad to work for it. We have seen a large part of the match industry in this country changed from an abode of misery, disease and desolation into a splendid, wholesome corps of good citizens who work in it. We find improvements developing among the workers in the iron and steel industries—in spots—that put old conditions to shame. And one of the first obligations of chemical industry, for its own benefit, is so to organize its work that its factory portals shall bid welcome to good men and true, to undertake their responsible tasks in conscience and in loyalty.

Readers' Views and Comments

Flotation Bubbles

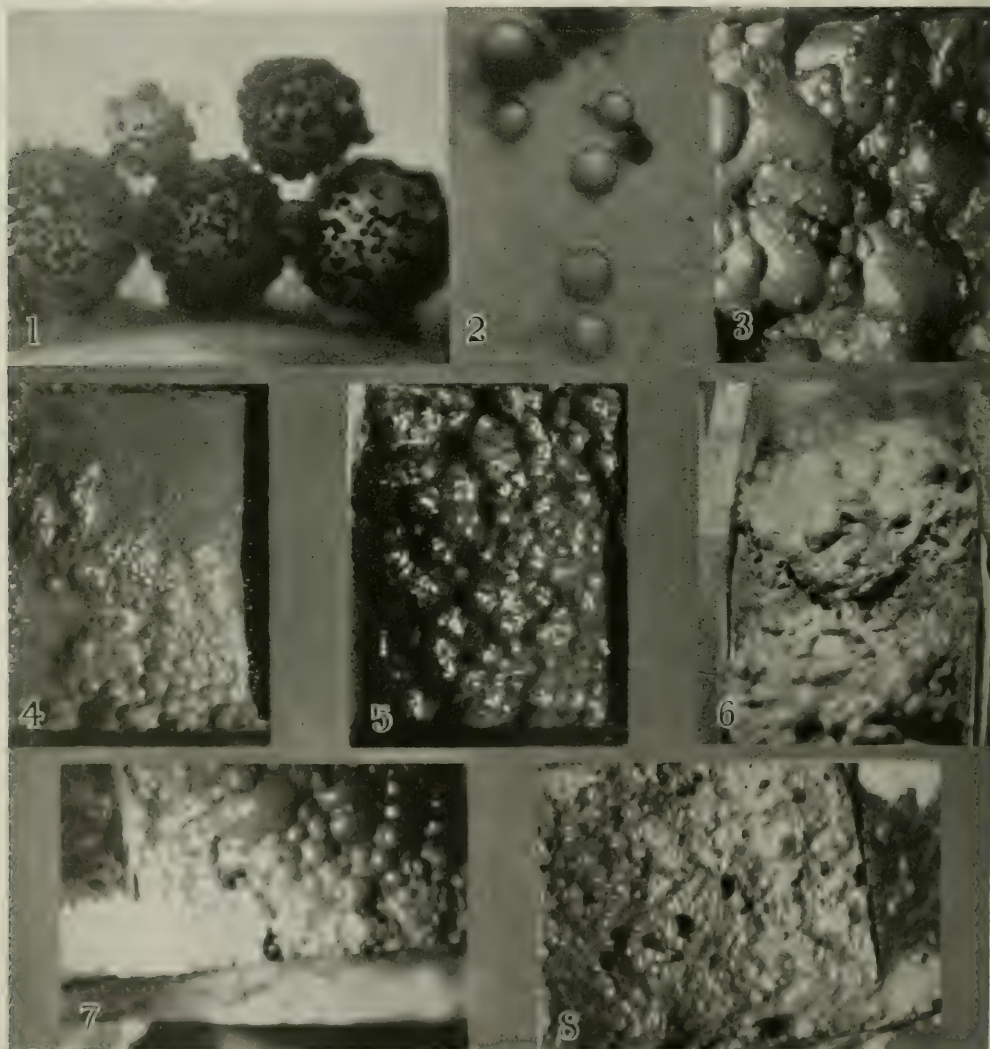
To the Editor of Metallurgical & Chemical Engineering

SIR:—In view of the great interest now taken in the flotation process, the photographs of flotation bubbles and bubble aggregates or froths, herewith reproduced, should be of interest.

Photographs 1 and 2 show the bubbles in the act of lifting the particles of minerals to the surface. They are cross-section views under water and were taken in a glass cell, using a B. & L. microscope and camera. Fig. 1 shows bubbles of a pine oil froth to which are

adhering particles of cassiterite, Fig. 2 pine oil No. 6 froth, the bubbles lifting small particles of galena. The magnification in both cases is 40 diameters.

Photographs 3 to 8 show the froth in a small experimental machine; they were taken from above the machine. All factors affecting the froth were kept constant. The impeller was stopped just before taking the picture. This allowed the small bubbles of some froths to coalesce as shown in Fig. 3 to the formation of large bubbles and as shown in Fig. 5 to the formation of a small bubble scum. The ore used was a dolomitic lead ore. Fig. 3 shows cresylic acid froth, Fig. 4 coal tar



FIGS. 1 TO 8—FLOTATION BUBBLES

creosote froth, Fig. 5 pine oil No. 6 froth, Fig. 6, wood creosote froth (correct amount of oil), Fig. 7 wood creosote froth (with an excess of oil), and Fig. 8 shows wood creosote froth, the same as Fig. 7, after adding oil from water gas tar. The froth has become a scum.

CHAS. Y. CLAYTON.

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Sources of Metal Loss in Copper Refining

To the Editor of Metallurgical & Chemical Engineering

SIR:—In Mr. Lawrence Addick's paper on "Sources of Metal Loss in Copper Refining," in METALLURGICAL AND CHEMICAL ENGINEERING for July 1 the question of moisture in copper bullion is touched upon. The article in question implies that in the Australian copper on which these tests were first made the moisture came from contact with bilge water during shipment. There is every reason to believe that this moisture was bosh water, consequently refiners of copper have reason to look in copper shipped by rail for moisture, just as much as in that shipped by vessel.

DONALD M. LIDDELL.

New York City.

Pacific Coast Waterpowers and Electrochemical Possibilities

To the Editor of Metallurgical & Chemical Engineering

SIR:—In your issue of Aug. 1, 1916, page 115, appeared a report of a meeting on the Niagara Falls Power Famine. In this meeting Mr. F. A. Lidbury, manager of the Oldbury Electrochemical Co. and a Past President of the American Electrochemical Society, stated that electrochemical industries cannot establish on this Pacific coast because of the excessive transportation charges to the territory now supplied by Niagara. Conversely, from this it would appear that if there is a market tributary to this coast Niagara would be out of the running for this business as compared to a plant operating on the coast.

As a matter of fact the market for electrochemical products is world-wide, and the establishing of such a large and varied industry requires the condition of accessibility to the markets of the world, viz., cheap transportation, which condition is satisfied by a location in a good harbor on tide water. There are such locations on the Pacific coast.

The average annual imports of Chilean nitrates into San Francisco exceeds 30,000 tons. To manufacture 30,000 tons of lime nitrate containing about the same amount of nitrogen, would require approximately 40,000 hp.

That California in the year 1912 had orders in Norway for lime nitrate in excess of the entire output of one of the large plants is a statement published in the Hearings Before the House Committee on the water-power bill.

Carbide.—There are probably more than 5000 tons of carbide used on this coast yearly. The establishing of new oxygen plants both in the States of Washington and California indicates an increasing use of carbide. In 1913 Chile imported from Germany over three and a half million kilos and Australia imported 14,155 tons, 85 per cent of which came from Norway and Sweden.

Ferro-alloys.—California is now shipping to the East chrome and manganese ore, and it is only a matter of reasoning that the ferro alloys could better stand high freight rates than the crude ore.

Cyanide.—The Pacific Coast is a more central dis-

tributing point for potassium or sodium cyanide than is Niagara.

Caustic.—At Pittsburg on San Francisco Bay there is now in operation a caustic and bleach plant established by people thoroughly conversant with and interested in similar plants in the East.

To the question: "Why do not electrochemical industries establish on this coast?" I would answer: "They are establishing."

E. P. KENNEDY,

President Speer River Project.

San Francisco, Cal.

The Determination of Chromium in Ferrochromium

To the Editor of Metallurgical & Chemical Engineering

SIR:—The following simple method for the determination of chromium in ferrochromium has proven, after a year's usage, both rapid and accurate.

The procedure consists in fusing the alloy with sodium peroxide, forming Na_2CrO_4 , dissolving the melt, and, after boiling to destroy the excess of peroxide, which has a strong tendency to reduce chromium in acid solution, acidifying with sulfuric acid and titrating the resulting dichromate solution by the usual method with tenth normal ferrous sulfate solution. The following outline is worked out for ferrochrome which contains about 70 per cent chromium: For alloys of different composition one may modify the amount of sample taken or the size aliquot titrated within reasonable limits.

Weigh accurately one gram of finely pulverized alloy (50 mesh) and mix thoroughly with 25 to 35 grams sodium peroxide. This may be accomplished by stirring the mixture with a stiff platinum wire in either a nickel or an iron crucible of about 40 c.c. capacity in which the fusion is to be made. A layer of sodium peroxide is placed on top of the mixture and the crucible gradually heated over a Bunsen burner to a dull cherry red until the contents is entirely fused. The heat is now lowered, keeping the mixture molten at a very dull red, nearly black heat for fifteen minutes. Gradually raise the heat once more to a dull cherry red and then allow the crucible to cool.

Place the crucible and contents in a one-liter beaker with 250 c.c. of water. Cover and allow the reaction to proceed. When finished, remove the crucible and cover carefully, washing with hot water. Boil the contents of the beaker vigorously for about twenty minutes to destroy the excess of peroxide. Acidify with a considerable excess of $\frac{1}{2}$ sulfuric acid and concentrate, if necessary, to a volume of about 300 c.c. Cool and transfer to a 500 c.c. volumetric flask and fill to the mark with water.

An aliquot of 50 c.c. is now titrated in the usual way against freshly standardized N/10 ferrous sulfate solution. This may be conveniently carried out by filling a 100-c.c. burette with the dichromate solution and titrating back and forth until a satisfactory end point is reached. The titration may also be carried out by adding an excess of standard N/10 ferrous sulfate solution to a 50-c.c. portion of the solution prepared for analysis and titrating back to a blue end point with N/10 potassium permanganate solution. This end point may be properly identified by treating 50 c.c. N/10 $\text{K}_2\text{Cr}_2\text{O}_7$ (standardized by pure iron) plus sulfuric acid in the way described.

For the sharpest end point the solution must be perfectly cold.

One c.c. N/10 ferrous sulfate is equivalent to 0.001743 gm. chromium.

A. F. MACFARLAND.

John A. Crowley Company,
Detroit, Mich.

The Iron and Steel Market

While September has not brought more active conditions in the steel market than obtained in August it has brought an accretion of confidence that the time when the pressure on the mills for deliveries is a long way off. The scarcity of material for this year's delivery has been accentuated, partly by reason of additional buying and partly by reason of the hot weather being prolonged and causing the curtailed rate of production to obtain for a longer period than normal.

Steel prices have shown a further hardening tendency. Bars, plates and shapes are better established at the advances of a month ago. Iron and steel pipe has been advanced one point, or about \$2 a ton, on butt weld sizes and two points on lap weld sizes, black, no change being made in galvanized. The new cards are dated Sept. 7. An advance in sheets is predicted for the near future, based on the expectation that the fourth quarter price on sheet-bar contracts will be \$3 to \$5 a ton higher than that obtaining for the third quarter.

Production of pig iron was a shade smaller in August than in July. The production in the first half of the year was 19,619,522 gross tons, but during July and August the furnaces fell 190,000 tons short of maintaining that rate, and the curtailed rate bids fair to continue through September. While October, usually a very favorable month for furnace operation, will doubtless show a heavy output, the prospect is that the official statistics will show smaller production of pig iron in the second half of the year than in the first half, although the second "half" of the year contains two days more.

There is no doubt that there was a considerable reduction in pig iron stocks during the first half of the year, while it is also a fact that new open-hearth furnaces have been completed month by month, whereby consumptive requirements certainly increase while it is impossible to make more pig iron. The general influence has not worked out thus far, perhaps, because the hot weather has curtailed the output of steel works very considerably since July 1. It is very easy to conceive an acute pig-iron scarcity developing within the next few months. That would quickly be reflected in the market. From the low point of December, 1914, basic pig iron at valley furnaces have advanced from \$12.25 to \$18, or \$5.75, while billets have advanced from less than \$19 to more than \$45, or in excess of \$26 a ton. If higher prices should be demanded for pig iron the steel works would have no difficulty in finding the money with which to pay.

Exports of iron and steel commodities that are reported by weight amounted to 496,000 gross tons in July, against 526,772 tons in June and 540,549 tons in May, the record month. Exports in the seven months totaled 3,112,000 tons, representing a rate of 444,000 tons a month, or 5,300,000 tons a year. In the same period British exports average 312,000 tons a month, and these exports were made up largely of material for the United Kingdom's allies. Until lately British exports were always greatly in excess of those of the United States.

Iron Ore

By a decision announced Sept. 5 by the Interstate Commerce Commission freight rates from Lake Erie docks to most Central Western points are revised, and on an average there is a reduction. New tariffs are to be filed by Dec. 1, and the new rates are to go into effect April 1, 1917. The rate to the Pittsburgh district is reduced from 88 cents to 82 cents. Monessen is taken out of the Pittsburgh district and given a rate of 96 cents, while on the other side Neville Island is taken

out and given the 70-cent rate which is retained for Aliquippa. Johnstown, formerly with a rate of \$1.02, is classed with Monessen. Wheeling is kept with Pittsburgh. The Pittsburgh rate was formerly 96 cents, but had been reduced to 88 cents when the commission ruled that the rate to Pittsburgh should not be higher than that to Wheeling, then 60 cents. Apart from the pecuniary importance of the decision the outstanding feature is the close application of the yardstick to the map. Only a few years ago the railroads were still insisting that the complicated rate structure would not permit of ton-mileage consideration of rates. The new rates as just stated are not the rates that will be published, as the carriers are required to segregate 6 cents for dock charges, from the rail of the vessel to the car, publishing this 6 cents as a separate rate. Apart from this 6 cents there is 10 cents that is regularly charged the vessel, making 16 cents for unloading direct ore. The commission ruled several years ago that its jurisdiction over iron ore, as interstate commerce, began at the rail of the vessel at lower lake dock.

Wild chartering has lately been done at \$1 a ton clear to the lake vessel, against the regular rate of 50 cents established before the season opened, and it is understood there has been some chartering for next year at \$1. The latest predictions are that Lake Superior ore may be advanced \$1.25, instead of \$1, for the new season, which would apparently give the shipper a net advance of 75 cents, allowing for the increased lake rate.

Iron ore shipments down the lakes in August amounted to 9,850,140 tons, or a gain of 100,000 tons over the July shipments. The season total is now 39,215,864 tons, indicating that about 62,000,000 tons can be moved down the lakes this season, with the usual movement of about 1,000,000 tons by all-rail to the old furnaces, plus about half a million tons consumption by the two Steel Corporation furnaces at Duluth, put in blast for the first time about the beginning of this year, making 63,500,000 tons in all. The record season's movement thus far was in 1913, just a shade under 50,000,000 tons.

Pig Iron Strong

The movement in pig iron has continued, but is more marked in foundry than in steel-making grades. All markets are firm, and some show an advancing tendency. Southern iron is up 50 cents, to \$14.50, Birmingham, regaining half the loss it experienced earlier in the year, and the same is to be said of Chicago, which necessarily moves closely in harmony with Southern iron. Foundry iron at valley furnaces is up 25 cents, to \$18.50. The furnaces may soon conclude they have sold enough of their output at prevailing prices. If a definite scarcity of pig iron should develop, as is far from impossible, the market would advance by dollars a ton rather than by fractions.

Unfinished Steel Very Scarce

Offerings of soft steel billets and sheet bars for this year's delivery are only occasional, and of small tonnage, the scarcity being as pronounced as at any time. The market is purely a nominal one, at say \$45 to \$50. One interest, perhaps more, is selling for first half shipment at \$46 and upward. There are few consumers that could afford to pay \$45 or \$50 for steel, with finished steel prices at their present levels, but a finishing mill in position to profit by the premiums offered for early deliveries of some finished products could afford to do so.

The report seems to be correct that within the past fortnight two steel works have sold about 100,000 tons of billet discards for export, this following similar large

sales of more than a month ago, and it appears that the unwieldy accumulations of billet discards, arising in the manufacture of shell steel, are now quite well worked off. Some of the steel has been bought by consumers who desired the particular grade, but most of it has been taken by buyers who would much prefer to have ordinary soft steel.

Non-Ferrous Metal Market

Sept. 11.—Copper is strong and scarce on early shipments. Tin is unsettled, but prices remain fairly steady. Lead has improved and is in fairly good demand and spelter has also had a slight advance.

Copper.—The copper market is in a strong position and deliveries for the balance of 1916 are held at a higher figure. Scarcely any offers of prompt or September electrolytic are made by the producers, and 28 to 28½c. is asked for the small amounts offered. Domestic buying is good for futures, October electrolytic being quoted at 27.75, with November and December deliveries at 27.25. Export business is dull at the present time, but inquiries for copper are being made by Russia.

Tin.—The tin market is in a very unsettled condition, due chiefly to the difficulty and delay in getting permits for shipments to this country. During the last two weeks there has been alternate activity and dullness and at present the market is dull and easy, with September and October Straits held at 38.40c. November arrivals at 38.35c., and December at 38c. Banca tin is about 1c. under these prices. Deliveries into consumption in August amounted to 4335 tons, somewhat less than the average so far this year.

Lead.—This market is at present in a pretty strong position. The trust price is still held at 6.50c. New York, with independents asking 6.60 and higher for spot deliveries. Sales to Japanese buyers were reported on Sept. 8, and these had the effect of stimulating the market somewhat. Futures are quoted at prices but very little under the spot price.

Spelter.—Buying was on a good scale last week following a previous dull period, and the market closed higher at the end of the week. Prompt and September spelter is quoted at 8¾ to 8⅞c., with fourth quarter at 8⅝c. There is difficulty in securing freight room for export shipments and the market abroad has advanced. Exports in August were large and amounted to 11,352 tons.

Other Metals.—*Antimony* is dull, with Chinese and Japanese held at 12c. No import business is reported on this metal. *Aluminum* continues steady at 61c, *magnesium* is quoted at \$3.50 to \$3.75 per pound, *platinum* at \$60 per ounce, *quicksilver* at \$76 per flask. *Silver* is higher at 63¼c.

Coming Meetings and Events

American Institute of Mining Engineers, Arizona, Sept. 18-23.

Association of Iron and Steel Electrical Engineers, Chicago, Sept. 18-22.

American Peat Society, Washington, D. C., Sept. 21-23.

Mining and Metallurgical Society of America, New York Section, New York, Sept. 21.

Second National Exposition of Chemical Industries, New York, Sept. 25-30.

American Chemical Society, New York, Sept. 25-30.

American Electrochemical Society, New York, Sept. 28-30.

Technical Section, American Paper and Pulp Association, New York, Sept. 25-30.

American Gas Institute, Chicago, Oct. 17-20.

American Society of Mechanical Engineers, New York, Dec. 5-8.

American Institute of Chemical Engineers, New York, Jan. 10-13, 1917.

The New President of the Colorado School of Mines

Mr. Howard C. Parmelee, for the past six years Western editor of this journal, has been elected president of the Colorado School of Mines. In extending to him our congratulations, in which we are sure his many friends in all parts of the country will join us, we feel we are not overstating the case if we say that the famous Colorado School is equally to be congratulated on the selection of its new president.

Mr. Parmelee was educated at the University of Nebraska, where he received the degree of B.S. in 1897 and A.M. in 1899. He entered the employ of the Union Pacific Railroad as assistant chemist in their Industrial Laboratory in 1900. From 1901 to 1903 he was chemist



HOWARD C. PARMELEE, PRESIDENT, COLORADO SCHOOL OF MINES, GOLDEN, COLO.

at the Globe plant at the American Smelting & Refining Company. From 1903 to 1906 he was consulting chemist at Denver, Col. He entered editorial work in 1905 as editor of the *Mining Reporter* and continued in this position until 1907. From 1908 to 1910 he was editor of the *Western Chemist and Metallurgist*. In 1910 he became Western editor of *METALLURGICAL AND CHEMICAL ENGINEERING*.

His editorial work gave him wide acquaintance among metallurgical and chemical engineers throughout the country and provided him with an insight into the educational demands of those industries. This was further aided by his great activity in the work of technical societies. Mr. Parmelee was one of the organizers of the Western Association of Technical Chemists and Metallurgists and general secretary of the organization for five years. He is also one of the organizers of the Teknik Club of Denver and its secretary since its organization, about six years ago. He is a member of the American Institute of Mining Engineers, a manager of the American Electrochemical Society, and the president of the Colorado Scientific Society for the year 1916. He has been elected to several honorary scientific societies, Sigma Xi, scientific fraternity, at the University of Nebraska; Tau Beta Pi, engineering fraternity, at the Colorado School of Mines; Alpha Chi Sigma, chemical fraternity, at the University of Colorado.

While we sincerely regret the loss of Mr. Parmelee as active Western editor of this journal, we are glad to state that he has consented to stay with this journal in an advisory and consulting capacity to introduce his successor as Western editor, Dr. S. Fischer, Jr., into the work and insure continuity of editorial effort.

These have been six happy years of friendly editorial co-operation. We cannot express our wishes for Mr. Parmelee's future career better than in the hope that he will meet the big task before him as president of the Colorado School of Mines with the same resolute courage, the same genial resourcefulness, and the same decided success which have characterized his work in the past.

Program of New York Meeting of American Chemical Society

The general program of the fifty-third meeting of the American Chemical Society, which will be held in New York City, Sept. 25 to 30, during the week of the Exposition of Chemical Industries, is as follows:

Monday, Sept. 25

- 2.00 p. m.—Official opening of Exposition, addresses by Dr. Chas. H. Herty, Dr. Francis A. J. Fitzgerald and Dr. Arthur B. Daniels.
- 4.00 p. m.—Council meeting, Chemists' Club.
- 7.30 p. m.—Council dinner, Chemists' Club.
- 9.00 p. m.—Council meeting, Chemists' Club.

Tuesday, Sept. 26

- 10.00 a. m.—General meeting of the society at Horace Mann Auditorium, Columbia University, 117th Street and Broadway. Addresses of welcome by Mayor Mitchell of the city of New York, President Butler of Columbia University. Response by President Herty, followed by general papers.
- 2.00 p. m.—Public meeting, Horace Mann Auditorium, Columbia University. Addresses by speakers of national reputation (to be announced). Presidential address by Dr. Herty.
- 8.00 p. m.—Reception at Hotel Astor. Members American Electrochemical Society invited.

Wednesday, Sept. 27

- Morning.—Divisional meetings, Columbia University, Symposium on Colloids (theoretical).
- Afternoon.—Two industrial conferences. One at the Chemists' Club on American Dyestuff Manufacture and one at Grand Central Palace on Electric Steel.

Thursday, Sept. 28

- Morning.—Divisional meetings, Columbia University, Symposium on Colloids (applied).
- Afternoon.—Two industrial conferences. One at the Chemists' Club on Industrial Alcohol, Acetone, and Formic Acid, and one at Grand Central Palace on Glassware and Porcelain.
- Evening.—Invitation Smoker of the American Electrochemical Society.

Friday, Sept. 29

- Morning.—Divisional meetings, Columbia University, Symposium on Occupational Diseases in Chemical Trades.
- Afternoon.—Two industrial conferences. One at the Chemists' Club on Medicinal Chemicals,

and one at Grand Central Palace on Manufacture of Paper Pulp and By-products.

- 8.00 p. m.—Subscription Banquet at Waldorf-Astoria, members and wives, \$3.50. Guests at cost. The members of the American Electrochemical Society and the Technical Section of the American Pulp & Paper Industry are invited, with price same as to members American Chemical Society.

Saturday, Sept. 30

- Morning.—Meetings of divisions. Industrial Conferences at Chemists' Club on Oils and Motor Fuels. Industrial Conferences at Grand Central Palace on Miscellaneous Chemical Industries, and Convertibility of Plant.
- 11.00 p. m.—Exposition closes at Grand Central Palace.

Program of New York Meeting of American Electrochemical Society

The program of the fall meeting of the American Electrochemical Society which will be held from Sept. 27 to 30, in New York, in conjunction with the Second National Exposition of Chemical Industries, includes many interesting technical and social features. The hotel headquarters will be at the Hotel Astor.

On Thursday and Friday afternoons inspection of the exhibits at the Exposition will be the feature. On Thursday evening a complimentary smoker will be held at the Hotel Astor, to which the members of the American Chemical Society and all other visiting chemists and engineers are invited. On Friday evening a subscription dinner will be held at the Waldorf Astoria under the auspices of the American Chemical Society, to which members of the American Electrochemical Society are invited. The charge will be \$3.50 per plate for members of either society and their ladies. For guests the charge will be cost. On Saturday an all-day excursion will be held up the Hudson by the American Electrochemical Society. Members of visiting societies are invited up to the capacity of the boat.

The detailed program is as follows:

Wednesday, Sept. 27

Electrochemical day at the Exposition, Grand Central Palace.

- 8.00 p. m.—Individual theater parties.

Thursday, Sept. 28

- 9.30 a. m.—Reading and discussion of papers.
 - O. P. Watts and P. L. DeVerter, The Protection of Iron by Electroplating.
 - E. A. and L. T. Richardson, Atmospheric Corrosion of Commercial Sheet Iron.
 - O. C. Ralston and C. E. Sims, The Electrolytic Recovery of Lead from Brine Leaches.
 - H. J. Morgan and O. C. Ralston, Electrolytic Zinc Dust.
 - W. E. Koerner, Electrolytic Behavior of Tungsten.
 - S. Fischer, Jr., Electrolysis of Vanadium Salts.
 - L. D. Hammond, The Electrodeposition of Nickel.
 - F. C. Mathers and E. G. Sturdevant, Current Efficiencies in Nickel Plating Baths with Rotating Cathodes.
 - W. Blum, Deposition of Copper in Electrotyping Baths.
- 12.30 p. m.—Luncheon at Hotel Astor.

2.00 to 6.00 p. m.—Visiting the Exposition.

8.00 p. m.—Complimentary smoker at Hotel Astor.

Friday, Sept. 29

9.30.—Reading and discussion of papers.

C. F. Burgess, Characteristics of Small Dry Cells.

L. C. Turnock, Effect of Temperature on the Performance of the Edison Storage Battery.

Carl Hering, High-Temperature Heat Developed during Electrolysis.

F. A. Fahrenwald, The Possibilities of Developing Superrefractory Materials for Incandescent Lighting.

H. Schlundt, T. H. Leaming and Julius Underwood, Composition of the Ionization Currents Due to Equal Quantities of Radium Emanation.

M. J. Brown, A New Method for the Study of Silver-Peroxynitrate.

W. C. Moore, The Vosmaer Phenomenon.

Grinell Jones and M. L. Hartmann, The Equilibrium between Bromine and Potassium Bromide Solutions at 0 Deg.

12.30 p. m.—Luncheon.

8.00 p. m.—Subscription banquet at Waldorf Astoria under the auspices of the American Chemical Society.

Saturday, Sept. 30

All-day excursion up the Hudson River. Details will be given out at the registration booth, where also the tickets for the smoker and the excursion will be obtained.

The arrangements for the meeting are in the hands of the New York Section of the American Electrochemical Society, of which Dr. Colin G. Fink is chairman and Mr. J. Malcolm Muir, 239 West Thirty-ninth Street, is secretary. Mr. John V. N. Dorr is chairman of the Finance Committee.

Second National Exposition of Chemical Industries

When the Second National Exposition of Chemical Industries opens on Monday, Sept. 25, the public will have an opportunity of seeing collected together under one roof a remarkable collection of apparatus, machinery and products representative of chemical and allied industries. The educational value will be immense, as many processes will be demonstrated in actual operation and moving pictures of various industries will be shown. This is not an exposition which only the technically trained man can enjoy; on the contrary, everyone can find much of interest and value.

One exhibitor will operate a miniature plant making sulphuric acid by the contact process. The American dyestuff industry will be well represented, with raw materials, intermediates, finished dyes and dyed products shown by most of the important companies. One exhibitor will show the process of making one class of dyes, and will operate a complete refrigerating plant for this purpose. One group of chemical companies will show every step in the dyestuff industry—coal, coal-tar crudes, intermediates, dyes, and the alkalis, acids and salts necessary in the various steps.

Electrolytic cells for making caustic soda, chlorine and sodium hypochlorite form another interesting feature. The products of these cells will be shown, and also some of the uses of chlorine in chlorine derivatives, such as carbon tetrachloride, chlorobenzol, etc. A nitric acid condenser will be in operation, the Cottrell electrical precipitation process of removing solids and liquids from gases will be demonstrated, and it will be shown how it can be applied to the recovery of dust in cement plants.

The other features, including motion pictures, the

Bureau of Mines exhibit, the paper and pulp section, the Southern opportunity section, etc., which have already been commented upon in these columns, will prove most interesting to everyone. There are over 50 per cent more exhibitors this year than last, and the attendance will undoubtedly be almost double. The programs of the meetings of the American Chemical Society and American Electrochemical Society, which will be held in conjunction with the exposition, will be found elsewhere in this issue.

Status of New Tariff Law on Dyestuffs

The dyestuff tariff has at last become a law. The Revenue Bill H. R. 16,763, containing the dyestuff schedule, passed the Senate and House after going to conference last week, and was signed by the President on Friday, Sept. 9. It is a good bill in many respects; in one respect it cannot be considered fair to the dyestuff industry in this country, and it may be robbed of its effectiveness by one clause.

The bill as finally adopted was a compromise measure. Coal-tar crudes are admitted free; intermediates are taxed 15 per cent ad valorem and 2½ cents per pound specific; finished dyes, excepting alizarine and alizarine dyes, anthracene and carbazol, natural and synthetic indigo and all indigoids, medicinals and flavors, are taxed 30 per cent ad valorem and 5 cents per pound specific duty. The exceptions noted are taxed only 30 per cent ad valorem.

The bill as it originally passed the House was not entirely agreeable to the Senate, and it was the subject of considerable debate.

A hearing was given by the Senate Finance Committee during the last week in July to three members of a sub-committee of a larger committee originally appointed at a joint conference held in New York in March, (at which were present representatives of practically every industry affected by the dyestuff situation, including manufacturers of coal-tar products and all classes of consumers). This sub-committee made the following recommendation to the Senate committee:

"It is urgently recommended that lines 23 and 24 at the bottom of page 89, and lines 1 and 2 at the top of page 90 (Title V, Sec. 401), reading as follows: 'except natural and synthetic alizarine, and dyes obtained from alizarine, anthracene and carbazol; and natural and synthetic indigo and all indigoids, whether or not obtained from indigo' be omitted. Otherwise the sincere and rational attempt of H. R. 16,763 to establish a coal-tar industry in this country is liable to be entirely frustrated by that parenthetical exception."

The Senate struck out this clause, and provided that the bill be not operative until after the war, and the bill went to conference. After consideration by the conference committee the clause was put back with medicinals and flavors added, and the bill was made effective at once. It finally passed both Senate and House in this form. After five years a yearly reduction of 20 per cent in duty is to be made, and unless the American industry reaches 60 per cent of our consumption in five years the duties become ineffective.

Further parts of the argument presented to the Senate committee by the sub-committee above mentioned, representing practically all the large producers and consumers, are worthy of earnest consideration. The argument continues as follows:

"The bill, after imposing a general 30 per cent duty on colors and dyes embodied in Section 401, the specific rates designed to encourage the foundation of this industry in the United States. This section imposes for a period of five years or more a reduced duty of 2½ per cent on intermediates enumerated in Group 2, and 5¢ per pound on the finished colors and dyes enumerated in Group 3. But, an-

fortunately, the parenthetical exception above referred to cuts out from this special 5-cent duty 'natural and synthetic alizarin and dyes obtained from alizarin, anthracene, carbazol and natural and synthetic indigo and all indigoids, whether or not obtained from indigo.'

"The class of colors thus excepted from the operation of the act constituted 27 per cent in money value of all the dyes sent out from Germany to us in the year 1913 and German exports alone represented more than 80 per cent of the U. S. A. consumption of all colors in that year.

"The terms of the bill provide that the special duty shall cease unless an American industry shall have been built up in five years' time capable of furnishing 60 per cent in value of the country's consumption. This arbitrary deduction of 27 per cent of the industry will make the attainment of 60 per cent of the total, a practical impossibility.

"Nearly eight million pounds of indigo, 20 per cent paste, are annually imported at a value of one and a half million dollars; this is by far the most important single color imported, and no other color approaches a million dollars in value. The two classes—alizarin and indigo—already represent nearly 16,000,000 pounds by weight of our color imports out of a total of fifty million pounds, and if they were permitted to reach our shores at one-half the duty imposed on the others they would soon represent nearly all of our colors. Dyes obtained from anthracene and indigoids comprise every shade of color in the rainbow. The colors thus excepted by the bill may be used on cotton, silk, wool, leather, in making paints or for any other purpose for which the strictly aniline colors may be used. Taken on the average, the colors thus excepted sell at lower prices in the form in which they are sold than the so-called 'anilines.'

"Nearly all of the excepted colors are made either with or by a combination of anilin oil and salts. Turkey red, it is true, may be made without using anilin and indigo may be made without using it, but as a matter of fact, one-half of the indigo in the world is actually made by using anilin and (however made) 70 per cent of the weight of indigo consists of anilin in its final analysis or composition.

"And it is now recognized that the cheapest and most effective way to make indigo is by the use of anilin. And yet under this exception indigo made with anilin would escape the extra duty or surtax. All the other excepted colors contain as much as 30 per cent of their weight in anilin oil or its equivalent.

"And so, as was stated above, these colors dovetail into one another and it will be chimerical to expect to build up an anilin color industry in this country by a specific tariff whilst thus exposing it to attack from colors that contain anilin, compete with anilines and yet under the exception will not be classed as anilin colors.

"Furthermore, it may be stated that for the amount of indigo imported into this country in 1913 there was required 1,000,000 lbs. or 500 tons of anilin oil in its production, and the total anilin oil consumption of the country before the war was but 4,000,000 lbs. This exception, therefore, practically takes back with the left hand what has been given with the right. It presents the anomaly of attempting to build up that most important coal tar industry by a temporary dike or barrier and leaving the dike wide open over 27 per cent of its length.

"The duties provided by the act are at the best barely sufficient to offset in normal times the handicap of German priority and pre-eminence.

"The exclusion of the colors in question would open a way to evade the spirit of the law and would cause endless disputes calling for Treasury interpretations. The consumer would find himself forced to question the derivation of every color imported in the hope that it would be found to be included in the excepted class. Expert witnesses could show that blacks, blues and 90 per cent of all colors may be produced from alizarin, anthracene, indigo and carbazol. The European makers would immediately develop colors produced from the privileged group which have many superlatively good qualities, and soon the new tariff would be found almost as inefficient in building up this industry as we have just found to our cost that the old tariffs have been.

"The collateral importance of this industry must not be overlooked.

"The coal-tar industry has a direct bearing on the steel industry as also on the high-explosives industry, and this last is absolutely essential to national life and safety.

"Unless the coal-tar color industry can be put on a sound, independent and paying basis in this country, it will be impossible for the country to become independent of the world in the matter of those high explosives which are essential for military purposes.

"During the past thirty years a 30 per cent *ad valorem*

duty on so-called anilines, but leaving indigo, anthracene etc., on the free list, has utterly failed to produce any sort of coal-tar color industry in this country except a very small industry which depended on imported intermediates. There is no foundation whatever for the belief that a 30 per cent duty which was ineffective in the case of anilines would be effective to create such an indigo and anthracene industry in this country. The color industry is and should be considered as a whole. If exceptions are made which are to be wholly or partly duty free they would soon grow to be of more importance than the items not excepted, and this could have only one effect—to defeat the very object of the bill. No one would be tempted to invest money in making aniline colors so long as he could be exposed to competition by another group or class of colors paying a much lower duty."

Representative Kitchin of North Carolina, chairman of the House Ways and Means Committee, led the fight in the conference committee against the specific duty on alizarin, indigo, medicinals and flavors, and Ceasar Cone of the Proximity Manufacturing Company of North Carolina, one of the largest users of indigo in the country, persistently fought the duty on these products. Thus it might be said that one factory has won out against consumers and manufacturers employing 2,000,000 people.

The dumping clauses in the section on unfair competition are first-class. Provisions are made for the first time, controlling imports and subjecting importers to all the restrictions of American manufacturers. The anti-dumping clauses are practically the same as when the bill passed the House and Senate before going to Congress. They make it unlawful for any person to import goods and sell them at a lower price than the actual market price in the country of their production.

The actual text of Group III and Sections 83 and 84 are given below. Group I contains a list of the coal-tar crudes—these are admitted without duty—and Group II contains a list of dutiable intermediates. These are omitted.

"Group III. All colors, dyes, or stains, whether soluble or not in water, color acids, color bases, color lakes, photographic chemicals, medicinals, flavors, synthetic phenolic resin, or explosives, not otherwise specially provided for in this title, when obtained, derived, or manufactured in whole or in part from any of the products provided for in groups I and II, including natural alizarin and indigo, and colors, dyes, or color lakes obtained, derived, or manufactured therefrom, 30 per centum *ad valorem*.

"Sec. 83. That on and after the day following the passage of this act, in addition to the duties provided in section 82, there shall be levied, collected, and paid upon all articles contained in group II a special duty of 2½ cents per pound, and upon all articles contained in group III (except natural and synthetic alizarin, and dyes obtained from alizarin, anthracene, and carbazol; and natural synthetic indigo and all indigoids, whether or not obtained from indigo and medicinals and flavors), a special duty of 5 cents per pound.

"During the period of five years beginning five years after the passage of this act, such special duties shall be annually reduced 20 per centum of the rate imposed by this section, so that at the end of such period such special duties shall no longer be assessed, levied, or collected; but if at the expiration of five years from the date of the passage of this act, the President finds that there is not being manufactured or produced within the United States as much as 60 per centum in value of the domestic consumption of the articles mentioned in groups II and III of section 82, he shall by proclamation so declare, whereupon the special duties imposed by this section on such articles shall no longer be assessed, levied, or collected.

"Sec. 84. That paragraphs twenty, twenty-one, twenty-two and twenty-three and the words 'salicylic acid' in paragraph one of Schedule A of section 1 of an act entitled 'An act to reduce tariff duties and to provide revenue for the government, and for other purposes' approved October 3, 1913, and paragraphs 394, 452 and 514, and the words 'carbolic' and 'phthalic,' in paragraph 387 of the 'free list' of section 1 of said act, and so much of said act or any existing law or parts of law as may be inconsistent with this title are hereby repealed."

Glimpses of New Pacific Coast Industries in the Making

Impressions From a Flying Editorial Trip to California

To write down the impressions received on an all-too-short trip to California might seem preposterous, if it were not for the fact that it was just one more trip in a series. While none of these trips was extended enough and thorough enough to permit a complete detailed sketch to be made of what was seen, they all together have left a very distinct moving-picture effect of new Pacific Coast industries in the making. To bring this point out clearly is the object of this note, while more complete accounts of the various new industries are reserved for future issues from the pen of men directly connected with the different undertakings.

After a very hot trip through the Middle West a first stop was made in Denver. Through the courtesy of Dr. R. B. Moore of the Bureau of Mines we visited the radium plant operated jointly by the Bureau and the National Radium Institute. It is a very business-like affair and gives an unexpected impression of bigness of plant and operation. The process was described in detail in a paper by Dr. Charles L. Parsons in our Vol. XIV, page 51 (Jan. 1, 1916). The work will soon be completed and the plant will then be sold or dismantled. We comment on some aspects of the radium work of the Bureau of Mines in an editorial in this issue (page 275).

At Salt Lake City another stop was made and we enjoyed a very interesting forenoon at the University of Utah, where in the Mining Building the station of the Bureau of Mines, under Dr. Dorsey A. Lyon, has its headquarters. We hope to publish in one of our next issues an account from Dr. Lyon's pen of the very far-reaching and manifold researches carried out under his direction during the past two years. These researches have covered the most varied subjects, from flotation to electrolytic zinc and lead, and the recovery of zinc from low-grade ores by igneous concentration, and many other problems. It is a very well equipped laboratory, with some ingeniously designed home-made apparatus. From Dr. Lyon's laboratory more than one well-trained engineer has gone into metallurgical practice, and the industry has been the gainer. One of his most notable co-workers who is still with him is Mr. Oliver C. Ralston, well known to our readers by his work on flotation and electrolytic zinc and lead.

The University Club of Salt Lake City, at which we had the pleasure to lunch with Dr. Lyon, deserves a notice, as it represents a realization of what has been considered an impossibility in other cities. There is a very cozy clubhouse in the best residential street, and yet in most immediate neighborhood of the business life of the city, with library and roof-garden, and all appointments which make a clubhouse homelike. No wonder the financial conditions of the club are said to be the most flourishing of any club in the State.

From Salt Lake City we went straight to San Francisco, and the first side trip to study new developments was made to the Pitt River in Shasta County.

Electrochemistry Along the Pitt River

Pitt is a station, nothing more, on the Shasta route, a little beyond Redding, a night's ride from San Francisco. It serves as the starting point of a small so-called railroad line along the Pitt River up to Bully Hill. One of the stations along the scenically beautiful road is Heroult on the Pitt.

ELECTROLYTIC ZINC AT BULLY HILL

Bully Hill is a famous old mining and smelting center. There are many indications of the primitive opera-

tions from early gold mining days up the Pitt River. There is also the big Bully Hill copper smelter, owned by the General Electric Company, but not in operation now on account of the suit brought by the government for damage done by fumes to vegetation. There we had the pleasure to meet our good old friend Mr. C. A. Hansen, who has temporarily forgotten his old love, the electric furnace, and is busily and enthusiastically engaged in making electrolytic zinc in a large-scale experimental plant. A very interesting account of some of his work at Bully Hill was given by him in our issue of Feb. 1, 1916 (Vol. XIV, page 120). He is not now using rotating cathodes, but some from his former work were there for inspection. It is interesting to note that different ores respond differently to the electrolytic process. Some curious problems with respect to addition agents have come up. The process is to be used on a large scale at the Mammoth Smelter at Kennet (midway between Pitt and Redding), and Mr. Handley of this company has done considerable work on the process.

There is no doubt that electrolytic zinc is attracting very considerable attention. The number of metal-



WHERE THE MCLOUD CREEK JOINS THE PITT RIVER

lurgists from various zinc companies we met at Bully Hill was significant in this respect. We were especially delighted to meet again at Bully Hill the distinguished general manager of Amalgamated Zinc, Ltd., of Broken Hill, Australia, Mr. Herbert W. Gepp.

After much talk with many zinc experts, not all of the same opinion by any means, it would seem no rash prediction to say that electrolytic zinc has come to stay for good.

NOBLE ELECTRIC STEEL COMPANY

Midway between Bully Hill and Pitt lies Heroult-on-the-Pitt. It was sad to think that this is the last that is left in this country of the name of one who up to his death was a very good and true friend, but it is pleasant to say that now at least the place that bears the famous French electrometallurgist's name has become prosperous. The Noble Electric Steel Company has had a hard time in an up-hill fight.

When Mr. H. H. Noble, as president of the Northern California Power Company, with true pioneer spirit conceived the idea of introducing electric iron reduction and steel refining to the Pacific Coast, he had be-



NORTH FORK FEATHER RIVER, CAPABLE OF PRODUCING 600,000 HP.

sides cheap power (\$12 per horsepower-year) one very big asset—a really magnificent iron ore and limestone mine. This mine is still the biggest asset of the company.

The plant was started by Dr. Paul Heroult, who was assisted by Mr. N. Petinot, and pig iron was successfully made. Then came a series of administrations, each characterized by a new furnace design. They were all carefully worked-out designs, but they all proved commercial failures. Each of these furnaces was worked for a time and subjected to improvements, but had finally to be abandoned. Most of the furnaces are still there, and the part of the plant where they are is something like a furnace museum.

If at this late date we may venture a reason for this succession of failures, we believe we are right in saying that everyone of the different furnace designers tried too much and wanted to make efficiency a maximum at once. It was overlooked that the first aim must be to make the furnace work in continuous foolproof operation, and that when this is accomplished there will be time to look after finesses in the saving of heat units and other improvements. In trying to make a furnace theoretically perfect from the start, one is liable to introduce mechanical complications which will be fatal in operation.

It is to the great credit of the present manager of the Noble Electric Steel Company, Dr. W. W. Clark, to have recognized this fundamental principle, and to have made a complete success of the plant. Since he started operation of the first furnace on April 15, 1916, for making ferromanganese, it has been in continuous operation. Mostly ferromanganese has been made, but when there occurred a lack of supply of manganese ore, the furnace was switched over for the time being to pig iron making. Other ferroalloys have also been made, and it is the intention to go into ferrochrome manufacture, since it is recognized that ferromanganese made in the electric furnace is a war baby. It is also intended to make special steels.

The electric furnace now used is of utmost simplicity of design. In this respect Dr. Clark has gone back to the principle of Dr. Heroult, "simplicity first." It looks as though Dr. Clark is going to make a reputation for himself as a first-class operating man at Heroult-on-the-Pitt, and Mr. Noble deserves our hearty congratulations on the final success of his pioneer work.

A delightful automobile ride over the Cascade Mountains to Redding concluded an ideally perfect day.

A New Industrial Center of Growing Importance on San Francisco Bay

The chief trouble with San Francisco as an industrial center has been in the past the labor problem—the domination of the labor unions. (During our present visit it was the union of waiters and chefs of the many restaurants that were on strike, and on entering Tait's or Techau's we were told by red-ribboned gentlemen and ladies that no fair-minded man should patronize a place unfair to organized labor.) But the labor problem must be solved if San Francisco is to come to what is due to her as a manufacturing city in view of the many obvious very great positional advantages.

San Francisco Bay is already an industrial district of no small importance, and its importance is rapidly increasing. One of the best locations is Pittsburg, at the outlet of the Sacramento and San Joaquin Rivers into San Francisco Bay. It has tidewater transportation, besides three railroads, and it has fresh water supply from the two rivers. It is there that the new plant of the Great Western Electrochemical Company is located about which more will be said later, also the works of the Henry Cowell Lime & Cement Company. Then if we pass along the shore of San Francisco Bay, there are the General Chemical Company of California, the A. L. Smith Lumber Company, the Columbia Steel Company, the refineries of the Union Oil Company, Shell Oil Company and Arroc Oil Company, the Selby Smelter and the Mountain Copper Company, the Hawaii Sugar Company, the Giant Powder Company, the Hercules Powder Company, the Standard Oil Company (having here the largest single oil refinery in the world), and the Stauffer Chemical Company.

This is quite an impressive list as it stands. It shows that the positional advantages of the district are clearly recognized. If we add that in the near future considerably more electric power will be available on tide-water for which there will be no use for lighting, traction and domestic purposes, because the present supply for these purposes is sufficient, then with an excess of electric power available at reasonable rates the incentive to go into new manufactures is self-evident.

This brings us to the new power development of the Great Western Power Company.

GREAT WESTERN POWER COMPANY

It has been argued *a priori* (by a distinguished engineer in a report to his very distinguished company) that no permanent hydroelectric power could be had in California on account of its two seasons, the dry season and



POWER PLANT OF GREAT WESTERN POWER CO. AT LAS PLUMAS

the wet season. But this argument completely overlooks the possibility of regulating the flow of the rivers and storing the water in artificial lakes during the wet season and drawing it off during the dry season.

An excellent example is the development of the Great Western Power Company.

The power of the Great Western Power Company is derived from Almanor Lake—an artificial lake with an area of something like 20,000 acres, in the Feather River Canyon district, a three hours' ride by automobile from Keddie on the Western Pacific. This lake now covers what was formerly the "Big Meadows." By building a comparatively short dam in one corner of the valley it was possible to produce this artificial lake.

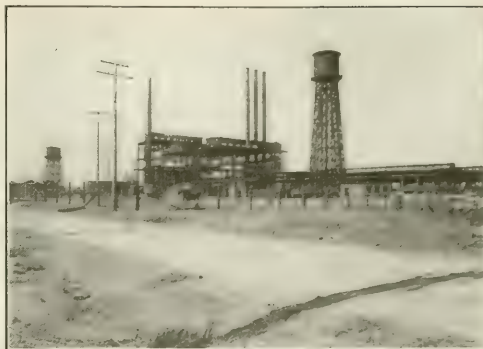
The present power house of the Great Western Power Company is at Las Plumas on the Feather River. It has a developed capacity of 60,000 kw., which may be increased to 80,000 kw. or 110,000 hp.

The new development, which is now under way, will utilize the same water in another fall near Belden, where a drop of 2000 ft. is available. This will yield 250,000 hp. so that the total will be 360,000 hp. It is hoped that this development will be completed in about a year.

By developing still other falls, the total that could be developed from the same water could be brought up to 600,000 hp. Besides, more water could be made available.

The interesting point is that the same water is made to work here in several plants in succession and moreover that after it has been used repeatedly for power development, it is finally used for irrigation in the Sacramento Valley where a 100-ft. irrigation canal has been built for watering rice fields; this will form eventually a transportation canal from the Sacramento River to Oroville. In view of this situation it might almost be said that the name Great Western Power Company is a misnomer in so far as it is a water company rather than a power company.

The Great Western Power Company has a splendid organization. At its head is Mr. Mortimer Fleishacker, who is also president of the Angelo-California Trust Co. and of the Great Western Electrochemical Co.—one of California's ablest constructive financiers. Mr. E. W. Beardsley is general superintendent and Mr. W. W. Briggs general sales agent. Mr. J. M. Howells, the hydraulic engineer of the company, is also the father of the company in that he discovered the possibility of creating the lake and built the dam. Mr. J. W. Beckman



GREAT WESTERN ELECTROCHEMICAL CO., PITTSBURGH, CAL.

is the chemical engineer of the company looking for uses of power in electrochemical plants. Thus Mr. Howells and Mr. Beckman may be called the pioneers of the head and the tail of the company.

To Mr. Beckman we are indebted for some unforgettable delightful days along the Feather River with a grand auto trip from Keddie to Almanor Lake and over to the Belden Trail (Yellow Creek trail) where the new 2000-ft. fall is to be developed. Our thanks for courtesies received are also due to Mr. Roberts in charge at Almanor Lake and to Mr. Cane and Mr. Menzel in charge at the power house in Las Plumas.

GREAT WESTERN ELECTROCHEMICAL COMPANY

The Great Western Electrochemical Company is an outcome of the conviction that if all the power which can be made available by the Great Western Power Company is to be utilized an outlet must be found in electrochemical industries. Mr. Mortimer Fleishacker is the president; Mr. John F. Bush (formerly general manager of the Hooker Electrochemical Company) is vice-president and general manager; Mr. J. W. Beckman is chemical engineer.

Ground was broken for the new plant at Pittsburgh on San Francisco Bay in February, 1916, and operation was started in the latter part of July for the production of caustic soda and chlorine by electrolysis of brine. The capacity is 2500 hp., the output 5000 tons of caustic soda and 10,000 tons of bleach. Experiments are under way for the manufacture of other chlorine products. Power is obtained from the Great Western Power Company at very reasonable rate.

The Moore Allen cell is employed. This is a diaphragm cell used by the Jessup & Moore Paper Company; it is very similar to the Townsend cell, but no oil is used.

The bleach made is sold principally for paper bleaching in the Pacific Coast States and in Canada, but as an indication of the peculiarities of the present time it may be said that some of the bleach has been sold to Sweden and Norway.

The caustic soda is sold chiefly to plants at San Francisco Bay, part of it in liquid form.

Messrs. Bush, Beach & Gent are the sales agents of the company. While caustic soda and chlorine are the first products of the company, the intention is to enter other electrochemical industries. Mr. Beckman has a vision as to the electrochemical possibilities of the Pacific Coast and he is strongly backed by the industrial and financial genius of Mr. Fleishacker. The develop-



BIG MEADOWS DAM FORMING LAKE ALMANOR, SHOWING SPILLWAY AND OUTLET TUNNEL, NEXT LARGEST ARTIFICIAL LAKE IN THE WORLD

ment of the company deserves close and friendly attention.

OTHER NEW DEVELOPMENTS AT SAN FRANCISCO

At Oakland, across the Bay, the Electro Alkaline Company has been operating for some time a small plant of twelve Whiting cells for the production of hypochlorite. With present prices the business is highly profitable.

In Visitation Valley, San Francisco, the Rankin process for fixation of atmospheric nitrogen is tried out in a 1000-kw. furnace, after experiments in a smaller furnace had been made in Nevada. No definite results can yet be announced. Mr. E. B. Bumsted, a civil engineer of San Francisco and the present president of the San Francisco Engineers Club, is backing the venture.

At the Berkeley station of the Bureau of Mines under Dr. Duschak much attention is paid at present to the cause of explosions which have occurred recently and repeatedly in oxy-acetylene welding plants along the Coast.

Mr. E. J. Fowler of the Pacific Foundry Company has made a great success with his non-corrosive "corrosion," while from Mr. E. L. Oliver of the Oliver Continuous Filter Company, we learn that his filter is entering the chemical field.

The chemical industries are moving in California, and it is a pleasure to watch them. Even a hurried business trip, with some things to worry about (not the least being the threatening railroad strike), is a source of continuous delight in sun-kissed California.

(A second article on Southern California developments will follow.)

Exhibitors at Chemical Exposition

In the following we give an alphabetical list, complete up to Sept. 13, of the exhibitors at the Second National Exposition of Chemical Industries, to be held in the Grand Central Palace, New York City, in the week of Sept. 25, 1916.

Abbe Engineering Co.; Abbe, Paul O.; Alberene Stone Co.; American Chemical Society; American Coal & By-Product Coke Co.; American Electrochemical Society; American Institute of Mining Engineers; American Synthetic Dyes, Ltd.; American Transformer Co.; American Synthetic Color Co., Inc.; Angel & Co., H. Reeve; Arnold, Hoffman & Co.

Badger & Sons Co., E. B.; Baker, J. T., Chemical Co.; Barber Asphalt Paving Co.; Barrett Company, The; Bausch & Lomb Optical Co.; Beckers, W., Aniline & Chemical Works; Beighley Electric Co.; Benzol Products Co.; Bethlehem Foundry & Machine Co.; Bristol Co., The; Brown Instrument Co.; Buffalo Foundry & Machine Co.; Butterworth-Judson Corporation.

Carborundum Co.; Carrier Engineering Corporation; Castner Electrolytic Alkali Works; Carolina, Clinchfield & Ohio Ry.; Celluloid Zapon Co.; Central Foundry Co., The; Chadwick-Boston Lead Co.; Chemical Catalog Co.; Chemical Co. of America; Chemists' Club, The; Coatesville Boiler Works; Codd Co., E. J.; Condensite Co. of America; Contact Process Co.; Corn Products Refining Co.; Corning Glass Works.

Day Co., J. H.; De Laval Separator Co.; Denver Fire Clay Co.; Detroit Range Boiler Co.; Devine Co., J. P.; Dorr Company; Dow Chemical Co.; Downington Mfg. Co.; Driver-Harris Wire Co.; DuPont, E. I., DeNemours Co.; Duriron Castings Co.

Edison, Thos. A.; Eimer & Amend; Electro Bleaching Gas Co.; Electrochemical Co., The; Electron Chemical Co.; Electrolytic Zinc Co., Inc.; Elyria Enamelled Products Co.

Fabra Co., Ltd., The; Foote Mineral Co.; Foxboro Co., The; Franco-Swiss Colours Co.; Freeport Sulphur Co.; Fuller Engineering Co.

Geissinger Regulator Co.; General Bakelite Co.; General Chemical Co.; General Electric Co.; German-American

Stoneware Works; Glens Falls Machine Works; Golden Chest Mine; Great Western Power Co.; Great Western Silica Co.; Greiner Co., Emil, The.

Hardinge-Conical Mill Co.; Harrison Bros. & Co.; Hemingway, Frank, Corporation; Hayward & Co., S. F.; Herold China & Pottery Co., The; Holz, Herman A.; Hooker Electrochemical Co.; Huff Electrostatic Sep. Co.; Huyck & Sons, F. C.

Industrial Filtration Corporation; Industrial Research Co.; International Equipment Co.; International Glass Co.

Kieselguhr Co. of America; Kleinschmidt & Co., F.; Koppers Co., H.; Koven & Bro., L. O.

Laboratory Supply Co., The; Lead Lined Iron Pipe Co.; Leeds & Northrup Co., The; Lehigh Car, Wheel & Axle Works; Lehigh Foundry Co.; Lehigh Stoker Co.; Lenz & Naumann, Inc. (American Apparatus Corporation); Life Saving Devices Co.; Little, Arthur D., Inc., Boston; Lungwitz, Emil E.; Luzerne Rubber Co.

Madero Bros.; Manufacturers' Record; Marden, Orth & Hastings Co.; Merck & Co.; Metals Disintegrating Co., The; Metallurgical & Chemical Engineering; Mathieson Alkali Works; Mine & Smelter Supply Co.; Mississippi River Power Co.; Monsanto Chemical Works; Mott, J. L., Iron Works; Multi-Metal Sep. Screen Co.

Nash Engineering Co.; National Aniline & Chemical Co.; National Gum & Mica Co.; Newark Department of Docks and Meadows; Newport Hydro-Carbon Co.; Niagara Alkali Co.; Nitrogen Products Co.; Norton Co.

Ohio Pottery Co.

Palo Company, The; Paper, Inc.; Paper Trade Journal; Patterson-Allen Engineering Co.; Pennsylvania Salt Mfg. Co.; Pfaudler Co., The; Precision Instrument Co.; Process Engineers, Ltd.; Product Sales Co., The; Prest-O-Lite Co., Inc., The; Pyroelectric Instrument Co.

Raritan Copper Works; Raymond Bros. Impact Pulverizer Co.; Research Corporation; Roessler & Hasslacher Chem. Co.; Ruggles-Coles Engineering Co.

Schaeffer & Budenberg Mfg. Co.; Schaum & Uhlinger, Inc.; Schutte & Koerting Co.; Scott & Co., Ernest; Scientific Materials Co.; Semet-Solvay Co.; Seydel Mfg. Co.; Sharples Specialty Co.; Shriver & Co., T.; Sidco Co. of America, The; Society of Chemical Industry; Solvay Process Co., The; Sowers Mfg. Co.; Squibb & Sons, E. R.; Stamford Mfg. Co.; Standard Aniline Products, Inc.; Stevens-Aylsworth Co.; Stone & Webster Eng. Corp.; Stuart & Peterson Co., The; Sturtevant Mill Co.; Sweetland Filter Press Co.; Swenson Evaporator Co.; Swiss Colours Co., Inc.

Takamine Laboratory; Taylor Instrument Companies; Technical Association of Paper & Pulp Industry; Tennessee Power Co.; Tennessee Coal, Iron & Railroad Co.; Textile Colorist; Thermal Syndicate, Ltd., The; Thwing Instrument Co.; Toch Bros.; Tolhurst Machine Works.

Uehling Instrument Co.; Union Sulphur Co.; United Gas Improvement Co.; United Lead Co. (Chadwick Boston Lead Co.); United States Bureau of Mines; United States Cast Iron Pipe & Foundry Co.; United States Bureau of Standards; United States Smelting Co.; Universal Fibre Co., Inc.

Valley Iron Works.

Weiller Mfg. Co.; Werner & Pfeleiderer Co.; West Pulverizing Mach. Co.; Westinghouse Elec. & Mfg. Co.; Whittall Tatum Co.; Williamsburg Chemical Co., Inc.

Zapon Leather Cloth Co.; Zarembo Co.

Chilean Nitrate Statistics for July

Chile's production and exportation of nitrate during July were both on a large scale according to *Commerce Reports*. There were produced in all the oficinas 5,312,776 Spanish quintals (of 101.4 lb. each) and the exports amounted to 5,674,088 quintals.

The market at Valparaiso, where almost all the transactions in the sale and resale of nitrate take place, was not very active during the month, and the change in price was slight. At the end of the month ordinary, or 95 per cent, nitrate was quoted for sale at about 7s. 5d. (\$1.80) per quintal alongside for delivery in the latter part of 1916. Nitrate for delivery in 1917 is held about a penny (\$0.02) higher per quintal. Refined nitrate, 96 per cent—1 per cent, sold as high as 7s. 10d. (\$1.90) per quintal, but for 1917 delivery concessions from this price down to about 7s. 8d. (\$1.87) were spoken of.

The Processes of the Organic Chemical Industry Used in the Manufacture of Intermediate Products

BY A. H. NEY AND D. J. VAN MARLE

There are six raw materials, derived from coal-tar or obtained in the by-product recovery of the coke-oven industry, from which the large number of the intermediate products are obtained. These six products are benzol, toluol, xylol, naphthalene, anthracene and phenol.

By submitting these raw materials to the action of different chemicals in succession, it is possible to obtain from one raw material different intermediate products. By changing the order in which we let these chemicals act, or by changing the proportions or physical conditions (especially the temperature), we are able to obtain different intermediate products with the same chemicals from the same raw materials.

The nature of the operation depends on the chemical we use, so that the action of one chemical on different products is very similar from a mechanical standpoint, and the apparatus in which the operation is carried out is essentially the same.

The most important operations are:

Nitration, carried out by means of nitrating or mixed acid, a mixture of nitric and sulfuric acid, by which the material acted upon is converted into a nitro-compound, and often followed by a reduction, transforming the nitro-compound into an amido-compound by the action of iron and hydrochloric acid.

Sulfonation, carried out by means of sulfuric acid of different concentration, by which sulfonic acids are formed, which are often converted into hydroxyl compounds by a caustic fusion, viz., by fusing with caustic soda in open kettles or in autoclaves under pressure.

Due to the chemical constitution of the products, often different products are formed in one operation. In the benzol-, toluol-, and xylol-series we distinguish these products as ortho-, meta-, and para-compounds, and as a rule either the meta- or the ortho-, and para-compounds are formed almost exclusively. From naphthalene two different products can be formed, the alpha- and beta-compounds. When more than one chemical agent acts on one of the raw materials, the situation becomes more complicated, and in most cases a mixture of different products is formed, which has to be separated. The anthracene compounds form a class by themselves, as the product obtained therefrom are dyes themselves, and they will therefore not be taken into consideration. The derivatives of phenol mostly are not prepared from phenol, but from compounds of the benzol-series, so that the whole field can be divided into two parts, the benzol- and the naphthalene-compounds.

A few examples will illustrate what has been said, and show how it is possible to obtain many intermediate products from these few raw materials.

By nitration of benzol nitrobenzol is formed, but by using the double amount of nitrating acid, the nitration can be carried further, and we obtain meta-dinitrobenzol, which contains two nitro-groups. By reduction of nitrobenzol, it is converted into aniline. Reducing meta-dinitrobenzol, however, we can prepare two products by reducing one nitro-group or both, which is possible by the use of a different reducing agent. With sodium sulfide only one nitro-group is reduced, and meta-nitraniline is formed; with iron both nitro-groups are reduced, converting meta-dinitrobenzol into meta-phenylenediamine.

To prepare the respective para-compounds, para-nitraniline and para-phenylenediamine, we have to start

from aniline, which first is converted into acetanilide by means of glacial acetic acid, then nitrated. The nitro-compound on saponification yields para-nitraniline, and after reduction para-phenylenediamine. A small amount of the ortho-compound is formed during the nitration, the less the lower the temperature is kept.

That the order in which the chemicals act can have a decided influence on the product formed can be shown by the action of chlorine gas on benzol, forming chlorbenzol, which by nitration is converted into a mixture of ortho- and para-nitro-chlorbenzol. Nitrating benzol first, and chlorinating the nitrobenzol, we obtain meta-nitro-chlorbenzol.

In the naphthalene series the temperature is the deciding factor on the nature of the product formed, as by sulfonating naphthalene both alpha- and beta-naphthalene-sulfonic acid are formed, the latter mostly at high temperature, the former at low temperature.

By caustic fusion we can obtain the alpha- and beta-naphthol, the latter operation only being carried out commercially. Sulfonating beta-naphthol it is theoretically possible to obtain seven different beta-naphthol-sulfonic acids, but only two are formed. By a larger amount of sulfuric acid two disulfonic acids are obtained, and in both cases it depends on the temperature, which one predominates in the mixture.

The classes of compounds members of which are of commercial value are:

Nitro-compounds, containing the NO₂ or nitro-group.

Amido-compounds, containing the NH₂ or amido-group.

Chlorine-compounds, containing the Cl or chlorine group.

Hydroxyl-compounds, containing the OH or hydroxyl group (phenols and naphthols).

Alkyl-compounds, containing the CH₃ or methyl group, or C₂H₅ or ethyl group.

Acetyl-compounds, containing the COCH₃ or acetyl group.

Acids-compounds, containing the COOH or carboxyl group.

Sulfonic acids, containing the SO₃H or sulfonic acid group.

Aldehydes and ketones, containing the CO or carbonyl group.

They are generally obtained by the action of nitrating acid (nitration), iron (reduction), chlorine (chlorination), caustic soda (caustic fusion), alcohol or other agents (alkylation), acetic acid (acetylation), carbonic acid (carboxylation), or sulfuric acid (sulfonation) respectively.

These operations we will now discuss more in detail.

Nitration

By the action of nitric acid on organic compounds of the aromatic series, a group of products is formed which are called nitro-compounds. The action of nitric acid consists in the replacement of a hydrogen atom by the NO₂ or nitro-group. In a few cases not a hydrogen-atom but another group, such as the sulfonic acid- or carboxyl-group is replaced. Examples of practical interest being the nitration of the alpha-naphthol sulfonic acids, which are formed by sulfonation of alpha naphthol, and are converted into dinitronaphthol or its sulfonic acid, commercially known as Naphthol Yellow S., and the nitration of phenol-trisulfonic acid, which is converted into picric acid, all three sulfonic acid groups being replaced by nitro-groups.

It is possible to replace more than one hydrogen-atom by a nitro-group, but in most cases not more than three are replaced, in this way forming mono-nitro, dinitro and trinitro compounds. The preparation of mono-

nitro-compounds is comparatively easy, but it is more difficult to make a second or third group enter, and especially in the last case a certain excess of nitric acid is required, and it is necessary to increase the concentration of the acid and to carry the separation out at a higher temperature. Much heat is generated during the reaction, and the reaction, therefore, has to be kept under control by means of artificial cooling.

In the benzol series three different nitro-compounds can be obtained, the ortho-, meta- and para-compounds. It depends on the groups already present in which position the nitro-group enters, and as a rule it enters in meta-position to a nitro-, sulfonic acid, carboxyl- or carbonyl-group, and in ortho- and para-position to a chlorine-, bromine-, alkyl-, amido- and hydroxyl-group. The proportions in which the ortho- and para-compound are found depend to a large extent on the temperature, the para-compound being formed in increasing amount of lower temperature. In case two or more groups are already present, it is hard to predict which compound will be formed owing to conflicting influences of these groups, and often a mixture of different compounds will be the result of this nitration. In most cases a fairly homogeneous product will be formed, and by-products will only be present to a small extent, so that a nitration is one of the operations which is carried out in the organic chemical industry with the greatest success.

In the naphthalene series two different nitro-compounds can be formed, the alpha- and beta-compound. The nitro-group here enters almost exclusively in alpha-position, a second nitro-group entering in position 5 or 8 to the first. In case any sulfuric acid groups are present, the nitro-group enters by preference in position 3 or 8 to one of these groups.

NITRIC ACID

The form in which the nitric acid is generally used, is as nitrating acid or mixed acid, which is a mixture of nitric and sulfuric acid. During the reaction water is formed, which tends to dilute the acid, and in case straight nitric acid is used the acid would become so dilute that it would be no longer effective, necessitating the use of an excess of nitric acid to complete the reaction, which excess, on the other hand, may cause a small amount of higher nitrated products to be formed, which would cause serious trouble in subsequent operations.

The sulfuric acid present in the mixture will bind the water formed during the reaction, and the nitration can, therefore, generally be carried out with the theoretical amount of nitric acid, which also means a considerable saving, as nitric acid is much more expensive than sulfuric acid, and the waste acid, which contains only a small amount of impurities, can be mostly recovered and used for other purposes. The greatest advantage, however, is that whereas nitric acid has a strongly corroding effect on iron, the action of nitrating acid is only slight, and allows it to be shipped in drums, and to carry the nitration out in cast-iron kettles, which makes it possible to manufacture this class of products on a large scale. The presence of sulfuric acid also makes it easier to keep the reaction under control, and the only disadvantage is that much heat is generated by the water which is formed and the sulfuric acid, which causes a material loss of time, as most nitrations have to be carried out at low temperature.

In certain cases the sulfuric acid determines the place in which the nitro-group enters the molecule, and its presence, therefore, can be objectionable unless a method is adopted to counteract its influence. This can be best illustrated with the example of the nitration of aniline, which gives amido-benzol, and from which two

important products are derived, meta- and para-nitraniline. The amido-group directs the nitro-group in para- and to a smaller extent in ortho-position, but as it has basic properties, it forms with the sulfuric acid an acid sulfate, which causes the nitro-group to enter also in meta-position, so that the result of the nitration is a mixture of three products, which would have to be separated. By first converting aniline into acetanilide, its acetyl-compound, by means of acetic acid, it is possible to neutralize its basic properties and prevent the formation of acid sulfate, so that now almost exclusively the para-compound is formed. The meta-compound can be obtained in an entirely different way, as we shall see later.

The nitrating acid, which is generally used, is a mixture of 1 part of nitric acid with 1-2 parts of sulfuric acid, but in a few cases where it is required to use a much more concentrated acid, the nitric acid can be mixed with fuming sulfuric acid, which is cheaper than using a mixture of highly concentrated nitric acid with sulfuric acid.

The nitric acid may be replaced by its salts, such as sodium nitrate, which when mixed with sulfuric acid forms nitric acid and sodium bisulfate, but as this causes mechanical difficulties, it is not often practised, even though it would be cheaper.

There is one class of products, those containing a hydroxyl group, such as phenol and alpha-naphthol, which react very violently with nitric acid and are easily oxidized. Dilute nitric acid already converts them into their nitro-compounds, and the nitration of phenol by means of dilute nitric acid has been carried out on a commercial scale, as the para-compound is used in the manufacture of para-amido-phenol. This process has been abandoned, however, as a much larger amount of the ortho-compound is formed and another way of preparation has been found. The dinitro-naphthol and trinitrophenol or picric acid are of much value, however, and in order to obtain these products, the naphthol and phenol are first converted into the sulfonic acids, the sulfonic acid groups being replaced by the nitro-group and any oxidation being prevented.

TEMPERATURE

In contradistinction to sulfonation, the temperature in nitration has no influence on the nature of the reaction-product, and is only of importance in regard to its purity. In the first place at higher temperature the nitration may be carried further, so that a small amount of a higher nitrated product may be formed, which, as already pointed out, may cause difficulties in subsequent operations. In the second place nitric acid is an oxidizing agent, and especially at high temperature the oxidizing action becomes more pronounced, and part of the material may be converted into products which are entirely valueless, which causes a loss of material and makes purification necessary. The presence of sulfuric acid, which tends to the formation of nitrosyl-sulfuric acid, a compound with strong oxidizing properties, also may cause oxidation, and it is therefore of the greatest importance to keep the temperature sufficiently low to prevent this action, especially when the material to be nitrated is easily oxidized. The oxidation is accompanied by the development of nitrous fumes, which may cause still more complications, in case the material to be nitrated can be reacted upon by nitrous acid. For example, the amido-compound, which may be converted into diazo-compounds and later in the process into hydroxyl-compounds, and the alkylated amido-compound and hydroxyl-compound, which are able to form nitroso-compounds by the action of nitric acid.

For this reason it also is advisable to protect the

amido- and hydroxyl-groups, and the least expensive way is to convert them into their acetyl-compounds by means of acetic acid, which can be easily saponified, in order to obtain the nitro-compounds. Formic acid and for the amido-compounds benzaldehyde also may be used for this purpose.

Much heat is generated during the reaction, partially due to the presence of sulfuric acid, and it therefore is necessary to supply the vessels in which the nitration is carried out with a cooling jacket, which serves at the same time as heating jacket, in case it is necessary to raise the temperature at the end in order to complete the reaction.

Last, but not least, the temperature should be kept under control, as at higher temperature the reaction may become too violent, which may cause serious explosions, two of the products of this class, picric acid and trinitrotoluol, obtained by nitration of phenol and toluol respectively, being used in enormous quantities as military explosives.

APPLICATION

The largest application for the nitro-compounds is found as intermediate products in the manufacture of amido-compounds. The simplest and best known member of this series is nitrobenzol, obtained by nitration of benzol, and converted by reduction into aniline. Enormous quantities are yearly produced, the production of aniline in the United States now being 15,000 tons, requiring the production of approximately one and one-half times its weight of nitrobenzol, to which has to be added the large amount used as solvent and for the manufacture of benzidine. Starting from toluol, xylol and naphthalene we obtain the intermediate products for toluidine, xylidine and naphthylamine, which are applied to a large extent in the manufacture of many azo-dyes, and themselves again can be converted into other valuable products. The nitration of toluol yields a mixture of the ortho- and para-compound, which can be separated by fractional distillation in vacuum, and freezing out the para-nitrotoluol from the residue. The para-toluidine has a larger value than the ortho-compound, while the para-nitrotoluol-sulfonic acid also is used in the production of the stillbene-dyes. The ortho-nitrotoluol can be converted into tolidine, which in its properties is very similar to benzidine. Commercial xylol is a mixture of ortho-, meta-, and para-xylol, which on nitration forms a mixture of not less than five nitro-xylols, of which the meta-compound is present in the largest amount and also is the most valuable. A separation here is not carried out.

Other nitro-compounds which are further reduced to amido compounds are those of benzol-sulfonic acid, acetanilide, dimethylaniline, benzoic acid, salicylic acid and benzaldehyde, used for the manufacture of metanilic acid, para-phenylene-diamine, dimethyl-meta-phenylene-diamine, amido-benzoic acid, amido-salicylic acid and amido-benzaldehyde respectively. Nitro-benzaldehyde itself is also used in the preparation of certain dyes of the triphenylenethane series.

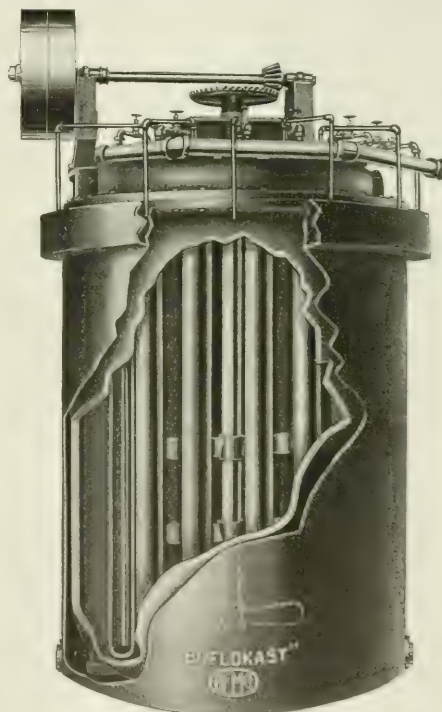
On further nitration dinitro-compounds are formed, the most important being dinitrobenzol and dinitrotoluol, in the last case the ortho- and para-nitrotoluol both being converted into the 2-4 dinitro-toluol, the ortho-compound at the same time forming a small amount of the 2-6 dinitro-toluol. Naphtalene on the contrary forms only one mono-nitro compound, but two dinitro-compounds, the 1-5 and 1-8 dinitronaphtalene, the first to a much smaller extent, but of larger value as it forms by treatment with zinc and concentrated sulfuric acid naphtazarine or alizarine-black, a very fast chrome-black. It has been tried to make use of

the 1-8 dinitro-naphtalene by making a sulfur-black from it, which however has not been able to compete with other blacks of this class.

Nitro-compounds are also used in the manufacture of azo-dyes, para-nitraniline, obtained by nitration of acetanilide, followed by saponification, being used in large quantities. When combined with beta-naphthol, para-red is formed. This dye being insoluble it is prepared on the fibre and can also be used in the paint-industry. It is remarkable that when a small amount of one of the beta-naphthol-sulfonic acids is added a much bluer shade can be prepared. The nitro-toluidine derived from para-toluidine also gives a valuable red lake. Para-nitraniline also is used for developing a number of azo-dyes on the fibre, which improves their quality.

Much attention has also been paid to the nitration of chlorbenzol, as the nitro-chlorbenzol by heating with caustic soda forms nitrophenol, which can be reduced to amidophenol. The para-amidophenol is of value as a photographic developer, and important medicinal products, like phenacetine are derived from it. Originally para-nitrophenol could only be made by nitration of phenol, when a much larger amount of ortho-phenol is formed, aside from the fact that the nitration had to be done with dilute nitric acid. The ortho-nitrophenol can be used for making anisidine and dianisidine, but for large quantities no outlet could be found. Dinitrochlorbenzol, when fused with sodium-polysulfide gives one of the best sulfur-blacks, which is now largely produced in the United States. When combined with para-amidophenol or dimethylaniline before fusion it will form a valuable sulfur-blue.

In the naphtalene-series nitrations are of importance for the manufacture of alpha- and naphthylamine-sulfonic



NITRATOR WITH COOLING TUBES—1600-GAL. SIZE

acids and amido-naphthol-sulfonic acids which belong to the most important constituents for many azo-dyes. By nitration of alpha-naphthol and its sulfonic acids nitro-compounds are formed, which themselves are used as dyes, those being known as naphthol yellow. This is the only practical application of a nitro-compound as a dye, others having been superseded by dyes with more desirable properties.

To this class of products also belong two explosives of high value, trinitrotoluol and trinitrophenol or picric acid, of which the high importance at the present time is well known.

APPARATUS

The nitrations are carried out in cast-iron kettles surrounded by a cooling jacket, and provided with an agitator. Even if not entirely necessary, it is preferable to build the kettles of acid-resisting cast iron, which last much longer than those of ordinary cast iron.

As the raw material can be a liquid or a solid, there are two different ways of carrying out the nitration. If it is a liquid the nitrating acid is run into the raw material, in the other case the acid being put in the kettle first, and the material being added gradually. The materials have to be weighed out accurately, a measuring tank placed on a platform scale being provided for this purpose, for the acid and the liquid material.

In most cases neither the raw material nor the nitro-compound mix with the acid, so that to prevent the formation of two layers an efficient agitator, run at high speed, has to be provided, as insufficient agitation will result in an incomplete nitration, and may allow the nitrating acid to accumulate without acting on the material. In this case the nitration may start suddenly and control may be lost of the operation. There are two types of agitators which have given satisfaction, one consisting of a right- and left-handed propeller, the other of a screw conveyor placed inside a cylinder. Nitrators are built up to 1600 gallons capacity, the larger sizes being provided with a series of tubes, suspended from the cover, through which cooling water is circulated, as jacket cooling here would be insufficient. Every tube is operated individually, and can be replaced in case of leakage without interfering with the operation.

According to the nature of the product, there are three ways of separating this from the waste acid. A liquid nitro-compound is separated from the acid in a lead-lined tank with conical bottom, and collected in a storage tank; a nitro-compound of low melting point can be separated from the acid after it has solidified in a flat, lead-lined tank, while a nitro-product of high melting point can best be separated on a suction filter or by means of a centrifugal, if necessary after diluting the nitration-mixture in a lead-lined tank. The waste acid can be recovered, and concentrated or used for other purposes. In all cases the product is washed with water to remove the last parts of acid.

A number of products like dimethylaniline and acetanilide are dissolved in sulfuric acid before nitration. In this case as in that of the sulfonic acids, where the sulfonation mixture is directly nitrated, the nitration mixture is a homogeneous liquid from which the nitro-compound can be obtained by diluting with water in a lead-lined tank, and sometimes by the addition of salt. The nitro-product is filtered off in a wooden filter press or on a suction-filter, according to its nature and washed free of acid.

Most of the nitro-compounds are reduced without purification. In many cases, where it is crystalline, small amounts of impurities, which adhere to it in a

liquid form, can be separated in a centrifugal. In a few cases where a purification of the product is necessary, this will depend on the nature of the product and the impurities.

In recent years different patents have been taken out, in which a process for continuous nitration has been described, which would make it possible to nitrate large quantities of material in a small inexpensive apparatus. The only product for which this process would be of interest would be nitrobenzol, as others are not produced in sufficiently large quantities. The apparatus consists of four small jacketed nitrators with high-speed agitators. The first and second ones are cooled, the last one is heated. The benzol and nitrating acid are introduced simultaneously in the first kettle in the correct proportions. The kettle is connected to the next one by a siphon, which is arranged in such a way that when the mixture reaches a certain level, it is gradually withdrawn at the bottom and flows into the second kettle, then into the third and the fourth, from which it runs into a separating tank. If this interesting process has found application on a large scale is not known.

Conventions of American Foundrymen's Association and American Institute of Metals

This is foundrymen's week at Cleveland, Ohio. Both the American Foundrymen's Association and the American Institute of Metals are holding their annual conventions, and under their joint auspices there is a big exhibition of foundry equipment, supplies, machine tools and accessories.

The programs of the technical sessions are very full. One session per day is held by either association. Among the papers there is a symposium on the results of closer co-operation between the engineer and the foundry, another one on the influence of gating on castings, another one on electric furnace practice. Some of the papers presented before the Institute of Metals are printed elsewhere in this issue.

Among the exhibitors may be mentioned the Armstrong Cork Company of Pittsburgh, Pa.; the Beighlee Electric Company, Cleveland; Brown Hoisting Machinery Company, Cleveland; Carborundum Company, Niagara Falls, N. Y.; Charles J. Clark, Chicago; Cleveland Blow Pipe & Manufacturing Company, Cleveland; Davis, Bournonville Company, Jersey City, N. J.; Joseph Dixon Crucible Company, Jersey City, N. J.; General Electric Company, Schenectady, N. Y.; Gisholt Machine Company, Madison, Wis.; Goldschmidt Thermit Company, New York; Hauck Manufacturing Company, Brooklyn, N. Y.; Herman A. Holz, New York; Imperial Brass Manufacturing Company, Chicago; Julius King Optical Company, New York; Lakewood Engineering Company, Cleveland; H. M. Lane, Detroit; Life Saving Devices Company, Chicago; Lincoln Electric Company, Cleveland; Monarch Engineering & Manufacturing Company, Baltimore; Multi-Metal Separating Screen Company, New York; Norton Company, Worcester, Mass.; Pangborn Corporation, Hagerstown, Md.; Prest-O-Lite Company, Indianapolis; Pyrotecrite Company, Chicago; Robeson Process Company, New York; Searchlight Company, Chicago; Sullivan Machinery Company, Chicago; Titanium Alloy Manufacturing Company, Niagara Falls, N. Y.; Union Steam Pump Company, Battle Creek, Mich.

Among the entertainment features will be a trip to a ball game Tuesday afternoon, a theater party Tuesday evening, an inspection trip to the Cleveland Blast Furnace Co.'s plant on Wednesday, and other trips.

Design of Factories for the Manufacture of Dyestuffs

By Percival Robert Moses, E. E.

President of Moses, Pope & Messer, Inc.

The great war, imposing as it did a practical prohibition of imports of dyes into this country, has caused a rapid development of the dye industry, but there seems to be a general lack of appreciation of the fundamental facts in connection with the design of plants for this industry, due to a lack of knowledge of the special problems to be met and solved, and as many of these problems have come before us in the design of such factories, an article on the subject of the design of factories for manufacturing dyes and chemicals appears to be timely, and probably useful to those contemplating building.

It goes without saying that under the existing conditions, with a famine existing and with dyes commanding prices more than 1000 per cent higher than the prices before the war, almost any kind of a plant, operated in almost any kind of manner should be able to make money, provided sufficient capital is available to tide over the period of making and correcting mistakes, but after the existing conditions cease the plants which have not observed the fundamental requirements for efficient manufacture will undoubtedly go to the wall.

GENERAL PROCESS

The general process of dye manufacture involves the mixing and heating of liquids, or liquids and gases or liquids and solids; the evaporation, crystallization and distillation of the resulting solutions, accompanied by filtering, drying and grinding in order to produce the finished product. The materials used are largely the products of the distillation of the light oils contained in gas or in tar, such as benzol, toluol, xylol, phenol, naphthaline, anthracene and solvent naphtha. From these are made a host of intermediates, such as betanaphthol, alpha-naphthylamine, anilin oil, and alizarine. These intermediates and the final dyes are formed by sulfonating with sulphuric acid, chlorinating by dry chlorine gas, nitrating with nitric or mixed acids. Acetic acid and hydrochloric acid are also used in connection with iron filings and zinc dust for reducing the nitrated bodies. Large quantities of caustic soda and caustic potash, when this is available, are used for melting the salt formed and removing the sulphuric acid. Lime, soda and occasionally potash are used for changing insoluble into soluble salts, and for neutralizing free acid.

In general, the process is one resulting in the formation of vapors and fumes, and as these are frequently extremely corrosive and in some cases explosive, and in still other cases dangerous to life, the problem of transferring liquids and holding these liquids in storage during the processes and preventing the vapors from escaping into the room or into the atmosphere in an objectionable state is one which has given rise to an immense amount of trouble, most of which could have been avoided with proper knowledge of chemical properties and substances and the material used to hold and convey them.

The same conditions make the problem of fire prevention of special moment. Hardly a week goes by without news of some chemical plant exploding or burning up. This problem can best be met by separate buildings for all processes requiring open fire and isolation of all processes using explosive or easily ignited materials, such as benzol, alcohol and gasoline.

Besides these special requirements, the nature of the processes result in chemical reactions which frequently develop heat, in which case it is necessary to cool the

solutions by cold water or in many cases by artificial refrigeration, and in some particular process artificial refrigeration is not sufficient, and ice must be made and used to get the benefit of the absorption of heat due to the latent heat freed in the melting of ice.

The proper and economical heating of the liquids lends itself to the development of the highest efficiency in the utilization of the energy in fuel. Heat is required in three degrees—if the term may be used—high, medium and low temperature heating. For example, in the sulfonation of one of the intermediates a temperature of around 350 deg. C. is required. This can only be obtained—as the product is inflammable—by the use of a highly heated circulating medium in the jacket, surrounding the kettle, such as oil or superheated steam. For this temperature nothing but direct fire will suffice to heat the circulating medium, or waste gases from other sources.

Moderate temperatures, however, are used to a large degree for distillation, boiling and evaporating. This can best be obtained by the use of exhaust steam from the power plant, which may be operated at a sufficient back pressure to give the desired temperature. In one of the plants we recently completed, turbines were installed and operated at a back pressure of 15 lb. per square inch and an initial pressure of 140 lb. The turbine, of course, used a very large amount of steam per kilowatt hour output, but as all the exhaust steam was afterward used for evaporating purposes the turbine acted merely as a reducing valve between the boilers and heating service, and the power was obtained substantially as a by-product of the supply of heat for the evaporating processes.

Low-temperature heating, such as heating of the building, heating of water—large quantities of hot water being required in the processes—can also be best furnished by the use of exhaust steam, the plan adopted varying in different instances, depending on conditions; for example, one of the power units may be arranged to exhaust at the lower back pressure required by the low temperature heating, or if there is only one power unit in operation, the lower pressure exhaust may be obtained from the lower stage of the steam turbine, or the 15-lb. back pressure line may be provided with an automatically controlled release into the lower back pressure line.

The condensation from the coils is returned to the boilers, or if there is danger of contamination a heat exchange may be effected by the outgoing condensation and the cold water on its way to the hot water heating tanks.

Reference has already been made to the need of refrigerating plants, and in the large dye plants these are of great importance, running up into the hundreds of tons capacity. Such refrigerating plants, and the condensation of the vapors in multiple effect evaporators and the reflux condensers require large quantities of water suitable for condensing purposes. It is, therefore, an essential requirement in the choice for a site for the plant that abundant water be available for condensing purposes. The water to be of such character as will not cause undue corrosion to the condenser, or scaling.

Abundant water, but not necessarily of the same character is required for the solutions, for boiler feeding and for washing filter presses and filtering apparatus. Compressed air is also necessary. It is used for blowing the acids from the tank cars into the storage tanks, and from these to the various measuring tanks, also for lifting liquids by means of montejus, and for blowing out filter presses, for agitating, and if oil is used as fuel, compressed air is used for atomizing the oil.

The plan of a dye plant is, therefore, very complex, as it contains all the apparatus required in the ordinary manufacturing establishment with the addition of refrigerating machinery, and elaborate ventilating systems. The materials used must be carefully selected to withstand the liquids and gases to which they are subjected, and the matter of fire prevention, as has been mentioned, is one of greatest importance and of considerable difficulty.

There is another question which is of vital importance in connection with the success or failure of the plant. A very large proportion of raw materials as compared with finished product is required in almost all these operations. For example, in the production of beta naphthol or phenol, approximately 16 tons of raw material, if the coal is included, are required for the production of one ton of finished product.

This condition carries with it several important sequences. The first is that the location of the plant under competitive conditions will spell success or failure, other things being equal. An advance in freight rates of 10 cents per 100 lb. is equivalent to from 1 to 2 cents a pound on the finished product, and on materials which are sold in great bulk, such as sulphur black and the intermediates this sum may represent the entire profit on the sale.

It is essential, therefore, that the plant shall be located so as to enable it to obtain its raw materials at the lowest possible cost, and for this reason a location on the water front where the freight rates are kept down by competition with water shipments, is essential, unless it is possible with some particular type of dye to locate close to a plant producing the greater part of the raw material required, in which case a saving on the freight rate on one material may make up for the higher freight rates on the other materials purchased. But the question of freight rates is one which should be considered and studied with the utmost care.

The second sequence is that the handling of all this raw material must be done with the minimum of labor. This means automatic handling of the coal and ashes, large storage tanks with compressed air for delivering acids and other raw materials (liquids) and in some cases pumps must be used to avoid danger of explosion. The material in transit should be handled by conveyors wherever possible or pumped, and provision should be made for the discharge of some waste products and the storage of others, pending the development of by-products from them.

This question of delivery of the products in transit from one part of the process to another is also one which involves problems not usually met in the ordinary manufacturing plant. The materials in transit are frequently materials which would tend to clog up the pipes or channels, and in such cases the size of pipes must be made large enough to minimize the difficulty, and clean-outs must be provided at every turn of the pipe, and space left for easily getting at these clean-outs.

In other cases materials tend to solidify (or freeze) in transit, and in these instances several methods are adopted depending on the nature of the materials, as for example, surrounding of the pipe carrying the material with a steam jacket, or where this is not necessary, with insulating covering, or in some cases by the injection of steam.

Many of the liquids carried are extremely corrosive, and this difficulty can only be met by choosing the type of material which is least subject to corrosion, as for example the use of lead pipe for weak sulphuric acid, iron pipe for fuming acid, silver or tin or enamelled lined receptacles for acetic acid; earthenware, glass and special acid-resisting irons have all their special advan-

tages and disadvantages which must be considered in determining the best solution for this part of the problem.

BUILDINGS

Building construction will depend upon local conditions, *i.e.*, the comparative cost of brick or concrete or brick and concrete and steel. For many of the processes, mill construction may be used, but generally speaking wooden construction should be avoided, and as between the other types of construction—the less exposed steel work the better, because of the corrosive action of the fumes of sulphuric acid and hydrochloric acid.

Where alkali fumes are present to any extent, wooden construction should also be avoided, so that on the whole a brick structure with possibly a reinforced concrete skeleton if cost conditions make this possible is the most satisfactory.

Such a building can be put up in New York for from 6 cents to 10 cents per cubic foot, which is equivalent to from \$1.80 to \$3.00 per square foot as the average height of such buildings will be about 30 ft.

The buildings are usually single-storied, part of them being high and part low, the high parts being used to accommodate the many-storied platforms necessary to permit gravity operation.

The other requirements of the buildings are little if any different from the ordinary factory construction. Good light is advisable but not as necessary nor advisable as it is in textile or similar mills. In fact, it is as well from a fire standpoint not to have any more glass than is necessary for the proper carrying on of the operations and in some chemical operations too much light is objectionable.

Ventilation is of the utmost importance, and besides the special ventilation required for the processes such as the liming, nitrating, dissolving in acid, and similar operations, good general ventilation must be provided. Many of the fumes are poisonous, and of course these may be led directly away and not allowed to mix with the general atmosphere. A great deal of vapor is evolved and wherever possible it is collected directly at the apparatus such as the liming tub and led through ducts out into the open air, but in many cases this is not possible. For this reason, good general ventilation is essential.

Where the processes of evaporation and crystallization are carried on in open pans it is frequently essential to prevent any dropping back of condensation from the roof or hood, as this may carry with it impurities sufficient to discolor the whole solution. This is particularly the case if any iron work is exposed.

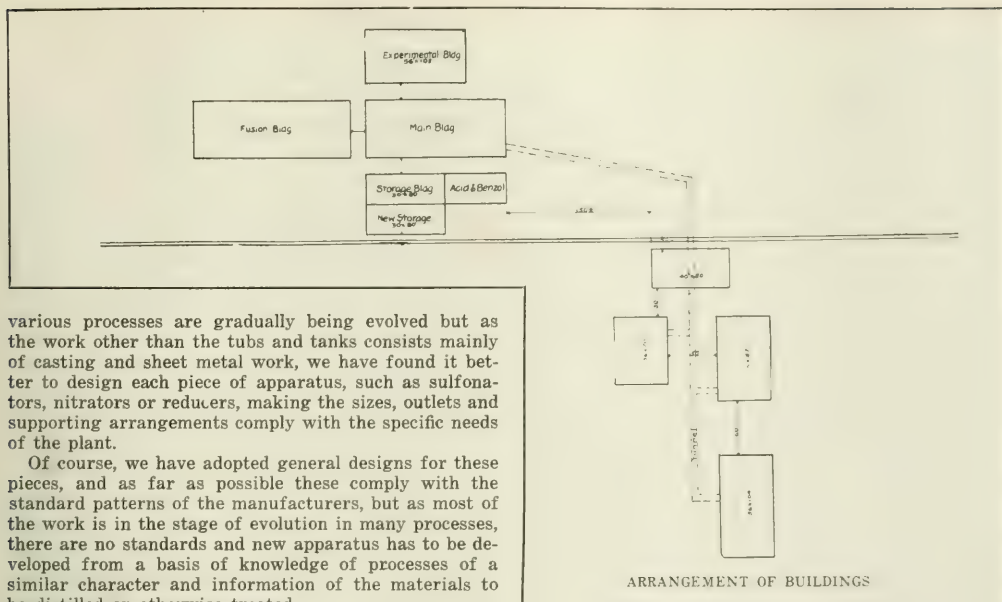
PIPING

As every dye or chemical factory is liable to change from one product to another according to market conditions, it is usual to arrange the piping in stacks or headers with additional outlets provided at frequent intervals by means of plugged tees or elbows. These groups or stacks of piping include cold and hot water, waste, high, moderate and low (exhaust) pressure steam, condensation returns, compressed air and gas. Acids, benzol, toluol, etc., are usually piped directly to the apparatus supplied unless there are several kettles performing the same operations, in which case headers are run.

Each material requires a particular kind of piping, as already noted in the general discussion.

APPARATUS

The same requirements as to choice of material in piping apply to apparatus. Standard apparatus for the



various processes are gradually being evolved but as the work other than the tubs and tanks consists mainly of casting and sheet metal work, we have found it better to design each piece of apparatus, such as sulfonators, nitrators or reducers, making the sizes, outlets and supporting arrangements comply with the specific needs of the plant.

Of course, we have adopted general designs for these pieces, and as far as possible these comply with the standard patterns of the manufacturers, but as most of the work is in the stage of evolution in many processes, there are no standards and new apparatus has to be developed from a basis of knowledge of processes of a similar character and information of the materials to be distilled or otherwise treated.

In all this work knowledge of chemistry is essential and the designing engineer should have with him a chemist to inform him of the probable reactions and the chemical effects occurring at each stage, including in chemical effects not only the gases, liquid or solid evolved but the heat developed and the temperature required to be maintained.

Questions of agitation are also important, as the profit on any product will depend under competitive conditions, other things being equal, on the percentage of yield, and this in turn will hang in many operations on the completeness of the mixture and the maintenance of correct temperatures during the process. This question of yields is most important and is the one most frequently forgotten in lay discussions. Almost any good organic chemist can produce a product, but unless the yield approximates the yield obtained by others, the process may be considered a failure.

While a great deal of delay, difficulty and loss has been occasioned by insufficient knowledge, poor workmanship and undue haste on the part of manufacturers of apparatus, the good ones are gradually becoming known and with the wider development of the industry keen competition will not only reduce the present abnormally high prices, but it will result in much better product.

Even under existing rush "war order" conditions, carrying with them labor unrest and hurried work, it is possible by careful inspection and selection to secure reasonable safety in the purchase of apparatus.

ELECTRICAL WORK

Many of the vapors affect insulating materials, and where wiring is exposed to destructive fumes it should be lead-coated. Otherwise the standard rubber and double braid insulated wire is satisfactory if enclosed in conduits, which, however, should be thoroughly protected by painting with suitable paint, such as "P & B" or asphalt paint, particularly at the couplings and outlet boxes.

Alternating-current motors of the brushless type are necessary where inflammable vapors exist, and as these

usually exist in some part of the plant, alternating-current is universally adopted. Motors must be of the squirrel-cage induction type wherever inflammable vapors exist or other fumes make it inadvisable to use sliding contacts as required in variable-speed alternating-current motors or in alternating-current motors designed for low starting current. Wherever possible, however, synchronous motors are used to bring up the power factor and over all efficiency. Care must be taken in the location of switch boxes, auto starters and oil-cooled transformers, as with many processes the fumes have chemical effect on the oil and in several cases coming within our own personal experience, motors have burned up and fires have started due to the chemical reaction between the oil and the fumes.

TYPICAL PLANT

The drawing reproduced above shows one of our recent layouts of a chemical plant which is producing two intermediates, with provision for the manufacture of two more in the immediate future.

A brief discussion will perhaps serve to illustrate the points mentioned.

The essential requirements taken care of are that the storage of inflammable materials such as benzol, and alcohol, is kept away from fire hazard, and the departments in which these chemicals are used are kept in entirely distinct buildings from the buildings housing the fusion and distilling operations requiring open flames. The buildings containing the inflammable materials are also kept as far as possible away from danger from locomotive sparks and the construction is essentially fireproof.

Provision is allowed for expansion of the plant by having ample area and by providing space around the buildings so that each building may be added to without interfering with the others.

All the power, steam and compressed air is derived from a central plant which permits of ready expansion of the manufacturing plant and also permits the efficient utilization of all the energy contained in the fuel

by making use of the exhaust steam from the operations of electrical manufacture and the making of compressed air.

Steam is supplied at 150 lb. from the boilers and at 15 lb. from the exhaust of the turbines and at 2 lb. from the other exhausts.

Railroad sidings, storage tanks with capacity for receiving tank-car quantities in addition to the necessary operating reserves together with conveyors and elevators for coal delivery to storage and from storage to the boilers take care of the handling of the raw materials at the minimum cost.

As far as consistent with the separation of the processes requiring flame from those requiring only steam and water, the process is routed on a straight line and where material has to be moved from one building to another because of the separation of processes, the handling of material is done by conveyors and elevators.

For the purpose of economy in handling and also to reduce the cost of piping and avoid stoppages, wherever it is possible to do so, the kettles or filters discharging into tubs are placed directly above the tubs into which they discharge. The measuring tanks which measure the liquids delivered into the kettles are placed above the kettles. This involves in some cases three and four-story platforms, but pumping is avoided with all its manifold objections. Wherever it is necessary to draw from tubs or tanks to discharge through filters or into overhead apparatus, it is our practice to use montejus instead of pumps as montejus require little if any attention. They operate with great rapidity and as they only use power when in operation they are far more efficient than the wasteful steam pump with its continual leakage and its low steam efficiency.

The plant discussed also complies with the requirements mentioned in the beginning of the article, as it is located on the shores of a large body of water which assures an ample supply of good condenser water and pure water for other purposes. The proximity of the plant to the source of supply of benzol, toluol and other raw materials, together with the competition offered by water shipments assures low freight rates for the other raw material not produced near at hand.

The problem of fire protection is solved by the segregation of the buildings, separation by fire spaces and the maintenance of water pressure by elevated tank and chemical fire extinguishers located throughout the plant, together with the usual safeguards required by the insurance companies, such as wire glass windows, fire-proof doors, etc.

The location is also a good one from the point of view of labor. The other requirements are also satisfactorily met, viz.: that labor shall be available at reasonable prices and that there shall be comparative freedom from restrictions as to the making of nuisances such as smells caused by the fumes and disposal of waste materials. Two specific instances have come to our knowledge where failure to consider the nuisance question is necessitating the removal of the plants.

COSTS

It is impossible to give any data on costs which will be reliable for any particular process.

The cost of the half dozen plants with which we have had to do, however, runs from \$150.00 to \$175.00 per ton of finished product per year, exclusive of buildings and from \$300.00 to \$350.00 a ton including land, buildings, water supply and power plant.

These prices are 1915-1916 prices and are probably higher than those that will obtain when normal conditions recur.

In some of these plants, the process starts from an intermediate such as anilin oil or a crude base such as naphthalene or benzol. In all cases the heavy acids, sulphuric, mixed and acetic were purchased and the products made were the simpler ones having large bulk sales. As these intermediates are themselves used in further processes to produce the finished dyes, it becomes necessary greatly to increase these figures when complex dyes are contemplated, as these involve many sulfonations, nitrations, filterings, washings, reducing, etc., and the recovery processes for the recovery of the various reducing agents and the efficient utilization of waste products are so many separate chemical processes.

The industry has already developed its feeding industries, i.e., the producers of caustic soda by the electrolytic process have added chlorination plants for making the monochlorobenzol used in the making of blacks; coke oven plants have added benzol, toluol and xylol and solvent naphtha recovery plants and are extracting their naphthalene and no doubt will soon be making the other crude bases such as anthracen and alizarine.

The importance of the industry to the United States cannot be measured by the tonnage or value of the dyes or intermediates produced.

The total present needs of this country are estimated at from 35,000 to 40,000 tons a year, but this means that use will be found for three or four hundred thousand tons of sulphuric acid, largely a byproduct of other processes; possibly 100,000 tons of caustic soda; thousands of tons of benzol, toluol, naphthalene, etc., and the production of these quantities of these materials means that the United States will be in a position to supply its own needs for defense if occasion should arise.

All these things are not only possible but they are probable, and observance of basic requirements and efficiency in planning together with protection against different standards of living and unfair competition are all that are needed for the development of a dye industry capable of supplying the needs not only of this country but of a fair share of the world.

The International Nickel Co. has acquired additional land at Bayonne, N. J., and will enlarge its plant at a cost of \$500,000.

Electric Welding at Electrical Exposition.—Electric welding of iron and steel will be one of the exhibits of the New York Electrical Exposition, which will be held in Grand Central Palace, New York City, Oct. 11 to 21. The exhibit is being arranged by the Arc Welding Machine Company of 220 West Forty-second Street, New York City, and Mr. O. A. Kenyon will be in charge. The public will have an opportunity of seeing all grades of welding accomplished in iron and steel, including structural pieces, plates and castings. Two arcs will be in operation equipped with automatic control so that the metal cannot burn by drawing too long an arc. The length of the arc is automatically controlled so that even the most unskilled worker cannot draw it beyond the point set. A special type of self-regulating generator designed particularly for welding purposes will be used. It consists of three units, one of which supplies the power, another of which regulates for constant current, and a third which takes care of the adjustment. This generator is used exclusively by the Arc Welding Machine Company. The United States Government is co-operating in the Electrical Exposition through the War, Navy and Commerce Departments, all of which will have comprehensive exhibits.

The Selection of a Method of Ore-Treatment

BY GEORGE J. YOUNG

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Present Methods of Ore and Mineral Treatment

Methods of ore and mineral treatment are broadly divided into (1) mechanical methods in which the mineral substances retain their identity, and (2) chemical methods in which one or more of the mineral substances are changed into other compounds. Mechanical methods consist of hand-picking, wet concentration, dry concentration, amalgamation, magnetic separation, electrostatic separation and flotation. Chemical methods are divided into smelting methods and those in which a solution of an active chemical agent like potassium cyanide or sulphuric acid is used to dissolve the valuable mineral.

The simplest mechanical methods are hand-picking and washing. Coal, iron ore, barytes and kaolin have their impurities removed by these methods. Hand-picking is frequently resorted to for the purpose of removing rich lumps of mineral from gold, silver, copper, lead, zinc, or other ores.

Next in complexity is wet concentration. In its crudest form it is used for the treatment of alluvial ores of gold, tin, platinum, and alluvial material containing monazite, rare earths and diamonds. The mechanical treatment of gold, silver, lead, zinc and copper ores involves more elaborate machinery and a much more complicated cycle of steps. Where wet concentration methods, which depend primarily upon differences in specific gravities of the constituent minerals of the ore, do not give satisfactory results, flotation, magnetic and electrostatic separation, which depend upon physical properties other than specific gravity, can be considered and their suitability determined.

Of the solution methods the cyanide process is easily of the first importance. It is used for the treatment of gold, silver and gold, and silver ores. Not infrequently wet concentration is used in conjunction with it. Next in importance is the leaching of oxidized copper ores by the use of solutions of sulphuric acid. While many solution methods have been proposed for the treatment of ores other than gold and silver, it is worthy of note that no one of them has passed beyond the experimental stage with the exception of the acid-leaching of copper ores. The field is, in spite of this fact, a promising one.

Smelting methods are applied to iron, copper, gold, silver, lead and zinc ores. Where ores are "high grade" they frequently are sold to smelters without preliminary treatment. In the case of "low-grade" ores some mechanical method as indicated before is necessary in order to prepare a rich product which is sent to the smelter for treatment.

The Examination of Ores

The examination of ores for the purpose of determining methods of treatment is in itself a common enough procedure and involves methods which are well known and in most cases easily applied. The elaboration of a systematic method of examination has the advantage of bringing to a student the possibilities of the problem and compensating for his lack of practical experience. There have been relatively few attempts to do this, and it is my purpose to present such a system and discuss its limitations.

Taking the Samples

Few ore deposits are uniform, and the samples which are to form the basis of our examination must be taken with the view of representing, as accurately as samples can represent, the extremes of variation and the averages of the ores which have been exposed in the mine workings. The deposits may present three distinct divisions,

the upper or oxidized portion, the intermediate or enriched portion, and the lower or primary portion. In some cases the ore problem may concern all three zones, while in others the oxidized portion may be relatively insignificant and the enriched portion important, or both the oxidized and enriched portions important and the primary zone unimportant. In other cases the primary zone may be of greatest importance. The relative importance can be determined by the relative quantities of ore and gross values represented by the three divisions. Whether one, two or three divisions are considered the procedure is essentially the same for each. An average sample is taken from each zone. This is done by making a number of sample cuts and combining the material from all. The possibility of dividing the ore into "first-class" or shipping ore and second-class or "mill ore" should be considered also. Here the metallurgist has to consider the mining problem. If it is possible to separately mine the two classes or readily separate them after breaking, then samples are taken of each class. This feature may apply to all three zones. The result of the sampling will be to give in the most general case from three to nine separate samples.

Oxidized	First Class	Second Class	Unseparated
Intermediate			
Primary			

No hard and fast rule can be laid down for the size of the samples. It is well to provide ample material and, if it is suspected that many tests will have to be carried out, from 500 to 1000 lb. of each sample may be advisable. For the small-scale tests the gross samples can be quartered to 100 lb. The taking of the samples is best done under the supervision of the metallurgist, and while they are being taken he should examine the general features of the ore in place. The physical nature of the ore, the manner in which it breaks and the nature of the mineralization are important points. A series of specimens of minerals typical of the ore and lumps of the ore itself should be gathered for future study. If it is obvious that stopes will be carried partly in the wall-rock, specimens and samples of the walls should be taken.

Samples and specimens for examination should be carefully marked and protected from any possible contamination.

Assays and Analysis

Each sample is reduced and a sample for assay and analysis taken. An assay for gold and silver and an analysis for the more important metals are made. While in many cases a complete analysis is unnecessary, I am very much in favor of making it. It will at least serve to check the possibility of the presence of unusual or unsuspected constituents.

Mineral Determinations

The lump-ore specimens are next examined and the minerals determined. Each mineral is separated and tested. Distinction is, of course, made between valuable and gangue minerals. The unusual minerals present are determined from the collection made at the time of sampling. Where it is possible to separate clean mineral fragments the specific gravity of the constituent minerals is determined. The percentage mineralogical composition is then figured.

Physical Examination

The specific gravity of the ore in the different samples is determined. This is not as easy as it appears. If the ore is compact, determinations upon lumps are sufficiently accurate. Several pieces should be tested and the average specific gravity calculated. If the ore is porous probably the best method is to determine the

approximate specific gravity by taking large pieces and determining their volume by sand displacement. The specific gravity is also calculated from the percentage mineralogical composition. The pore space of a given ore can be determined from the calculated and determined specific gravities. The hardness of the individual minerals and the approximate hardness of the ore should be tested and determined. Any definite structure such as banding, brecciation and planes of weakness should be noted. Plasticity or toughness or other pronounced physical characteristic should also be noted. For the physical examination the lump specimens are preferable to the test samples.

Mineral Association

The general nature of the mineralization of the ore will have been determined from studies made in the mine. The detailed study is made upon the type specimens previously collected. Ores from the standpoint of mineralization may be divided into massive, banded, laminated, disseminated, fracture-plane, and irregular. The terms are in common use and no definitions are necessary. Where only one mineral is associated with the gangue the size of the individual grains and aggregations of grains and crystals should be determined. In most ores the valuable mineral aggregates vary greatly in size, and it may be very difficult to determine the average size. In this case the extremes and the relative importance of each should be determined. For example, the aggregates may be for the most part of large size, say walnut size, or they may all be small, say of the size of wheat grains. Where relative terms are used for the description of sizes they should be defined within certain limits.

Aggregates may consist of two or more crystals. Note the number of crystals, the tenacity with which they adhere to one another in the individual aggregates, the shape of the aggregate, whether it be irregular, cubical, lenticular, sheet-like or tabular and the prevalence of the form habit. In addition, where two or more heavy minerals are associated, either as individual crystals or aggregates of crystals, note the nature of the association, the relative size and shape of the individual grains, and whether one mineral is included within the crystals of the other or they come together like the parts of a mosaic.

Where minerals are coarsely crystallized and the color and luster of the individual minerals sufficiently marked to admit of ready recognition, the examination of the lump ore or the broken pieces of the sample can be effected by use of a hand magnifying glass or by simple inspection. In the case of most copper, lead, zinc and some silver ores, the simple methods mentioned suffice. When the minerals are finely crystallized, intimately associated or differentiated with difficulty, then the method of examining a polished surface of the ore with the metallographic microscope is in order. A number of type pieces are selected and significant faces smoothed and polished. Individual mineral aggregates may be selected and prepared in the same way. Where differentiation is not pronounced reagents can be used to bring out differences in texture and color by etching. Thin sections of the ore are also prepared and examined with the petrographic microscope. In the case of a very complex ore the three methods enumerated above may be necessary, but it is surprising how much can be accomplished by the simple method of examining a number of broken fragments by the first method.

Crushing and Panning

Certain ores do not give satisfactory results by the above methods. Gold ores and many silver ores fall into this division. The relatively small quantity of the gold

and the smallness of the individual particles usually prevent its recognition. Where several sulphide minerals are present the ore may be coarsely crushed and separated by a needle into its constituent minerals. By weighing and assaying each portion the presence and proportion of gold in each can be determined. In the case of fracture-plane mineralization the mineral on the fracture planes can be scraped off and assayed and the association of gold with it determined. The heavy sulphide minerals in a gold ore are usually in a finely divided condition and it is not feasible to separate by picking. The simplest method is to crush a given portion through a 20, 30 or 40-mesh screen and then concentrate it in water by means of a pan or batea.

The products obtained are concentrate, sand and slime. The concentrate should be examined for the presence of "free gold." With a microscope the size, shape and nature of the gold particles can be observed. In some cases the gold particles can be seen projecting out of particles of sulphides or attached to pieces of gangue. By weighing the products and assaying, the proportion of gold in each can be determined. By amalgamating the gold in the concentrates the proportion of free or liberated gold can be determined. By comparing the results obtained from similar tests on more finely crushed portions it is possible to determine the proportion of gold which is free, the proportion which is intimately associated with the sulphides, the proportion which is intimately associated with the gangue particles and the proportion which is in an extremely finely divided condition and associated with the slime.

With silver ores a similar series of tests can be made and the distribution of silver minerals determined. In the case of sulphide silver ores amalgamation is not satisfactory. With oxidized silver ores the concentration test is apt to be unsatisfactory. With cinnabar ores and ores where the valuable mineral is in very small bulk and finely divided the concentration test can be applied if the difference between the specific gravities of the gangue and valuable mineral is marked. The test has the somewhat objectionable feature that different results are obtained with the same material where it has been crushed to different sizes. This is due to the fact that the valuable mineral is liberated to a different degree with each crushing. The proportion of valuable mineral slimes is increased also with increased fineness of crushing. By running parallel tests on three portions, each crushed to a different degree of fineness, results of sufficient value can be determined.

The products of each test should be examined with the microscope. The concentrate will show whether the silver or other valuable mineral has been separated in part from the other heavy mineral or not. The sand portions will show whether mineral is conspicuously locked up in the gangue grains. The microscopic examination of the slime portion usually is not satisfactory on account of the difficulty of differentiation. The microscopic examination is qualitative only; the assay of the portions gives the quantitative results. Mineral associations are determined directly from the microscopic examination, and indirectly from the comparison of parallel tests on different portions, in each of which the degree of liberation of the mineral particles is different.

Use of Solvents

Solvents can in some instances be applied advantageously to the examination of gold and silver ores. The solvents are solutions of potassium cyanide, nitric acid, nitrohydrochloric acid and hyposulphite of soda. The results which can be obtained by their use will be better understood by considering examples. Crush a

portion of the sample to a 40-mesh screen size. Thoroughly agitate it for from twelve to twenty-four hours with a strong cyanide solution, say, 2 per cent. Then throw the mixture on a filter and wash the residues thoroughly. Dry and assay the residue. The difference in assay values will represent the amount of soluble gold which has been liberated in crushing. Gold tellurides are not soluble in cyanide solutions, and if these be present a different procedure is advisable. The residue obtained after the use of the cyanide solution is transferred to a roasting dish and cautiously roasted in the muffle. It is then treated a second time with a cyanide solution and after washing is assayed. By determining the gold in the cyanide solutions the result of the test is: Weight of gold in final residue or unliberated gold; weight of gold liberated by roasting; weight of gold soluble in cyanide solution and liberated by crushing. By repeating the test on portions crushed to different sizes the relation between the degree of crushing and the degree of liberation of the gold can be determined.

If a silver ore is to be tested, in which the silver minerals present are cerargyrite and argentite the procedure is as follows: Agitate a known weight of the ore which has been crushed to a 40-mesh size with a 1 to 4 solution of sodium hyposulphite for twenty-four hours. Throw on a filter and thoroughly wash. Digest the residue with nitric acid, using the concentrated acid and boiling for at least an hour. Dilute, filter and wash and assay the residue for silver. The silver in the nitric acid solution can be precipitated by sodium chloride, filtered out and determined by fire assay or wet methods. The results obtained are: Weight and proportion of silver present as silver chloride; weight and proportion of silver present as silver sulphide; weight and proportion of silver not liberated.

Solubility tests are of value in indirectly determining the nature of the valuable compounds present where they cannot readily be identified by direct methods. Obviously they are more or less limited in their application and obviously the results are sometimes open to question.

Use of Heavy Solutions

This method of separating associated minerals is unfortunately of very limited application for ore examination. Most ore minerals have a high specific gravity, and while it is possible to separate the greater number of gangue minerals from the ore minerals, the separation of one ore mineral from another is the principal difficulty. The solutions which can be used are: Solution of potassium and mercuric iodides which gives a maximum specific gravity of 3.19. A solution of thallium mercurio-nitrate which gives a maximum specific gravity of 5.3 at 76 deg. C. A solution of zinc chloride which gives a maximum specific gravity of about 2.

The first solution could be used to separate heavy from light minerals or a light from a heavy gangue mineral. The second solution would apply to a large number of miscellaneous minerals, but the heavy minerals of gold, silver and copper, zinc and lead would not admit of separation. The third solution is used for separating dirt, pyrite, rock, etc., from coal. The use of heavy solutions is a last resort. If the direct methods of observation and chemical analysis and the indirect methods of determining solubilities fail to give satisfactory results, then try the heavy solution.

Conclusion

If the physical and chemical nature of an ore is understood, and if the nature and association of the minerals constituting the ore are known, then the method or methods of treatment can be decided upon. The limitations of ore-dressing, solution and smelting

methods from the economic, mechanical, physical and chemical standpoints are fairly well established. The mechanical appliances for drying, crushing, sizing, classification, concentration, sorting, washing, dewatering, filtration, magnetic separation, etc., have reached a high state of development. Mechanical appliances for conveying, elevating and excavating are available. Many examples of the arrangements of mills and reduction plants are to be found in technical publications. The metallurgist thus marshals three lines of thought, the ore, the fundamental steps in the treatment, and the mechanical appliances necessary to carry these out.

While a detailed study of the ore is essential it is not necessary in every case to carry out the general method described. The experienced metallurgist will know where the line can be drawn and can save himself unnecessary work. In addition certain tests are applied without, or with very limited, preliminary ore studies, and if favorable results are obtained the information may be sufficient to decide upon a method of treatment. Confirmatory tests are also carried out. These are first performed upon a small scale, and then the most successful repeated upon as large a scale as the available apparatus permits. Mill runs are often used for the determination of the details necessary for the design of the ore-treatment plant. They serve the additional purpose of confirming the studies and deductions of the metallurgist.

Golden, Colo.

The Ostwald Process of Oxidizing Ammonia to Nitric Acid

BY FRED C. ZEISBERG

Within the past year a great deal of interest has been shown in the "nitrogen problem" and considerable agitation has been rife with respect to making the United States independent of foreign supplies of nitrates in the event of war. One phase of this nitrogen problem is the catalytic oxidation of ammonia. The following article collects practically everything which has appeared in the literature concerning this process. It does not claim to present anything new, but simply aims to bring into a condensed and rational form the various references which have appeared from time to time.

The process of oxidizing ammonia to nitric acid is commonly known as the Ostwald process, not because this process was invented by Wilhelm Ostwald, but because the problem of the catalytic oxidation of ammonia was first attacked by him in a scientific manner and solved so successfully that this reaction could be used on the commercial scale. In the following pages all processes of oxidizing ammonia catalytically, and there are several of them, will be treated under the general head of the "Ostwald Process."

As early as 1839 Kuhlman¹ found that ammonia could be oxidized to nitric acid in the presence of catalytic agents. He mentions Cu, Fe, Ni, Pt and even Cu(OH)₂. Motay² mentions the use of lead manganate and permanganate, sodium manganate and lead chromate. In 1891 Warren obtained ammonium nitrite when ammonia and oxygen were passed over platinized asbestos at a dull red heat. Marston, in 1900, secured nitric compounds by passing the gaseous mixture over hot copper and other similar contact bodies.

That ammonia could be oxidized with ease was then well understood when Ostwald took up the study of the reaction in 1900. He discovered the conditions under which the reaction proceeded, and on the laboratory scale could easily obtain a yield, as HNO₃, on the NH₃,

¹Annalen der Chemie, 1839, 29, 281.

²Berichte der Deutschen Chemischen Gesellschaft, 1871, 4, 891.

taken, of over 85 per cent. Platinized platinum, *i.e.*, smooth platinum roughened by depositing upon it a thin layer of platinum sponge, was found the best catalyst, platinum black or sponge alone proving far too active. It was also found that only a thin layer of the catalyst worked best and that the gas mixture must be passed over the catalyst at a high velocity. A thick layer of catalyst or a low gas velocity caused the HNO_3 already formed to break down further into elementary nitrogen and water.

Having perfected the mechanical details of his process, Professor Ostwald, in 1902, applied for patents in the principal countries of Europe and in the United States. Because of prior publication of the essential features as scientific facts no patent was allowed in Germany. French Patent No. 317,544, English Patent No. 698 of 1902, Swiss Patent No. 25,881 and U. S. Patent No. 858,904, dated July 2, 1907, were allowed, however. The latter patent mentions the use, as catalysts, of palladium, iridium, rhodium, the oxides, especially the higher ones of manganese, lead, silver, copper, chromium, nickel, cobalt, vanadium and molybdenum; though platinum is best. The contact mass is heated to 300 deg. C., and the heat of the reaction then maintains it at the proper temperature. It is necessary to pass the gas at such a rate that a slight increase in rate would result in the appearance of unconverted ammonia in the exit gases, otherwise the yield will suffer. One of the claims also mentions a heat exchanger, whereby the heat of the exit gas is given up to the entering gases.

In 1909 a factory was built at Gerthe, near Bochum, Westphalia, with an annual production of 2400 tons of 53 per cent nitric acid. According to Norton¹ the operation of this factory has been very successful. A private communication states that from January, 1911 to August, 1912, this plant obtained an efficiency of 89.6 per cent on a monthly production of 130 tons of ammonium nitrate. The efficiency of conversion was 83 per cent and the efficiency of the absorption was 97 per cent. This plant operates on coal-tar ammonia, which is interesting in view of statements recently made in the literature that nothing but ammonia made from cyanamid was suitable in an oxidation process. Commercially, this factory is understood to have been a success.

According to another article² the above factory makes 2000 tons of ammonium nitrate per annum. This product has never appeared on the market, so it is presumably taken by the German government. In 1912 and in 1913 this company paid 8 per cent dividends to its stockholders.³

In 1910 the process was purchased by the Nitrates Products Co., Ltd., London, who took over the Gerthe plant. This company was promoted⁴ by Mr. A. S. Barton and reorganized under the name of the Nitrogen Products & Carbide Co. and is capitalized⁵ at £2,000,000. A new plant was erected at Vilvorde, Belgium, which produced 40 to 50 per cent nitric acid, higher strengths being produced by concentrating with sulphuric acid. Nitrates, Ltd., built cyanamid works at Alby, Sweden, and Notodden, Norway. In addition it expects to develop 400,000 horsepower in Iceland at the Ditterfoss, and three additional water power sites in Norway to produce a total of 600,000 horsepower. Recent articles⁶ indicate that the present name of this company is the Nitrogen Products & Carbide Company, and that their finances have been considerably mismanaged,

so that it has been necessary to assess the stockholders. No nitric acid is being made by them at the present time, their only factory, at Vilvorde, Belgium, being in the hands of the Germans.

A more recent article⁷ states that the experience of countries other than Germany and Belgium has been very unfavorable as regards the Ostwald process, and that it is doubtful whether a single Ostwald plant is now in use outside of Germany.

The fact that no patent protection exists in Germany results in the greatest secrecy being observed in connection with the details of the process, and it is practically impossible to find statements of much value in the literature. This is especially true since the outbreak of the European war, no articles of any authoritative nature having been published recently.

The original converters were so constructed that an exchange of heat occurred between the incoming gas and the outgoing gas. This served not only to keep the catalyst at the proper temperature of 300 deg. C., because of the strongly exothermic character of the reaction $\text{NH}_3 + 2\text{O}_2 = \text{HNO}_3 + \text{H}_2\text{O}$, in which ninety-seven calories are evolved⁸, but also served to regulate this temperature, even with considerable variations in the rate of gas flow. The thickness of the catalyst layer and the gas velocity are so chosen that the time of contact between the two does not exceed one one-hundredth of a second.⁹

The proportions between the NH_3 and the air can be varied considerably. If an excess of NH_3 is used ammonium nitrate is the end product. If the NH_3 and air are so proportioned that the relation is that shown in the equation $\text{NH}_3 + 2\text{O}_2 = \text{HNO}_3 + \text{H}_2\text{O}$, and no water is dripped on the absorption towers, the maximum strength of nitric acid theoretically obtainable is 77.8 per cent. Ostwald himself¹⁰ states that no less air should be used than represented by the equation $2\text{NH}_3 + 7\text{O} = 2\text{NO} + 3\text{H}_2\text{O}$. In this case passing the gases very rapidly would result in obtaining a mixture of ammonium nitrate and ammonium nitrite in the exit gases.

According to Camille Matignon¹¹ the above equations do not represent the reaction correctly, as at the temperature of the reaction neither NO , nor HNO , can exist. The equation should hence be written $2\text{NH}_3 + 5\text{O} = 2\text{NO} + 3\text{H}_2\text{O}$. Of course, if an excess of air is used the NO would readily be oxidized to NO_2 , as soon as the temperature is sufficiently reduced. This process of oxidation begins as soon as the temperature drops below 600 deg. C., but cannot become complete until the temperature drops to 140 deg. C.¹² At this lower temperature, moreover, the reaction velocity is very low, so that an appreciable time must elapse until the reaction becomes complete.

Apparently the only diagram of a converter ever published is one recently appearing¹³ in an abstract of an article by G. Schüpphaus in *Metal und Erz*, 1916, Vol. XIII, 21. In this converter the catalyst is a platinum gauze, electrically heated to 700 deg. C. The gases enter below and pass upward through the gauze, no heat exchange being effected. At this temperature the conversion is almost quantitative, steam and nitric acid (HNO_3) being the end products, which would indicate that the reaction equation is $4\text{NH}_3 + 5\text{O}_2 = 4\text{NO} + 6\text{H}_2\text{O}$.

To keep the gauze heated, electricity is supplied at 25 volts and 135 amp., *viz.*, 3.375 kw. No definite state-

¹Special Agents Series No. 52, U. S. Dept. of Commerce and Labor.

²Electrical Review (London), 1911, 69, 531.

³Chemical Trade Journal & Chemical Engineer, 1915, LVI, 553.

⁴Journal of the Society of Chemical Industries, 1915, XXXIV, 125.

⁵Chemical Age (Amsterdam), 1914, 18.

⁶Chemical Trade Journal & Chemical Engineer, 1915, LVI, 45 and 553; 1915, LVII, 20.

⁷Scientific American Supplement, Sept. 25, 1915.

⁸Electrochemical and Metallurgical Industry, 1906, IV, 137.

⁹U. S. Patent No. 830,000 of 1902.

¹⁰U. S. Patent No. 858,904.

¹¹Chemical Trade Journal & Chemical Engineer, 1914, LIV, 179.

¹²Transactions American Electrochemical Society, 1909, Oct. 28, 29, 30.

¹³Metallurgical & Chemical Engineering, 1916, XIV, 425.

ment is made as to the capacity of a converter, but judging from a description, included in the article, of an ammonia gas purifying apparatus connected with the factory, three converters handle from 125 to 1250 kg. of NH_3 per day. Hence one converter can probably handle about 240 kg. per day or 10 kg. per hour. Since at 85 per cent conversion, 10 kg. of NH_3 will make 31.5 kg. of HNO_3 , 100 kg. of HNO_3 will require about 10.75 kw.-hr. to keep the catalyzer hot.

The amount of platinum necessary to effect the conversion is about 47 grams per 100 kg. of HNO_3 per twenty-four hours.¹⁰ The platinum loss due to wear and tear is about 3 per cent per month, and the elements have to be completely renewed once a month. Since fairly high prices can be obtained for platinum scrap the cost of renewal is the cost of supplying the platinum due to loss and the cost of exchanging the scrap platinum for new platinum.

It has not been found possible to ascertain the dimensions of a converter, but what information is available would point to the use of only small converting units, containing perhaps not more than 50 grams platinum per unit. The converters are built of iron up to the contact element, and beyond this of iron lined with aluminium. According to a patent¹¹ to Ostwald (German No. 207,154) nickel steel is not attacked by hot, nitrous gases and it can hence be used in place of aluminium-lined iron. At a point far enough away from the converter for condensation to occur, the gas lines must be made of an acid-resisting material, such as chemical-ware.

Since this process is a catalytic one, it suffers from the disadvantages of all catalytic processes, namely, the contact substance is "poisoned" by certain substances, which must be very carefully removed from the entrance gas by a suitable purification treatment. It is presumably for this reason that statements have appeared to the effect that only ammonia from cyanamid is suitable for this process, and that ammonia from coal tar, even when carefully purified, is likely to cause trouble by poisoning. An interesting bit of information from the other side is that the Oesterreichische Verein für Chemische und Metallurgische Production¹² has patented (German Patent 276,720), a process of purifying ammonia from cyanamid with caustic alkali and earth alkali solutions. When this was not done it was found that despite a careful filtration of the gas, to remove dust, the platinum contact elements became brittle and covered with a coating of silicic acid, after being in use only a short time. This was due to the presence in the gas of silicon, phosphine and acetylene.

To show that considerable work has been done on the oxidation of ammonia by investigators other than Ostwald, there are shown below several patents. Thus Frank and Caro (German Patent No. 224,329), propose the use of thorium oxid, or thorium oxid in combination with the oxids of other rare metals.

Fr. Baeyer & Co. of Elberfeld (German Patent No. 168,272), use cupric oxid, ferric oxid, etc. A current of air containing 4 to 5 per cent NH_3 is passed over the catalyzer heated to 600-750 deg. C. Above 650 deg. the NH_3 is converted into N_2O exclusively.

Jones, Morton & Terzief (U. S. Patent No. 1,037,261) use the plumbates of magnesium, zinc, aluminium or cadmium, heated to 700-750 deg. C. The conversion to N_2O is practically complete and the heat of reaction is sufficient to maintain the catalyzer temperature with but little pre-heating of the gases.

Rohmer (U. S. Patent No. 1,096,392, assigned to Farbwerke vormals Meister, Lucius und Brüning),

patents the addition of only sufficient air to NH_3 , so that the hydrogen of the ammonia removes all the oxygen of the air. The exit gases contain then only nitrogen, steam and oxids of nitrogen. By removing the two latter by condensation, pure nitrogen, available for the manufacture of ammonia by synthesis, is left. This corresponds to French Patent No. 453,845.

Schick (U. S. Patent No. 971,149, assigned to Chemische Fabrik Griesheim Elektron) patents the manufacture of a catalyzer suitable for causing the oxidation of ammonia. Tile is dipped in a platinum chlorid solution, dried and heated, causing the deposition of platinum black. The tile is then baked, causing the platinum to collect in minute globules. This catalyzer is claimed to retain its efficacy much longer than the platinized platinum recommended by Ostwald.

The above list does not claim to be complete. It is inserted simply to show that there are many investigators working on this particular problem. It is probable that of the processes mentioned above, the one of Frank and Caro has been developed to the greatest extent. Thus, Frank S. Washburn¹³, president of the American Cyanamid Company, states that there has recently been developed a new process for the oxidation of ammonia, which does away with the limitations of the Ostwald process. The units can be made large or small and their cost is rather low.¹⁴

It is reported¹⁵ that the Frank and Caro process of oxidizing ammonia has been developed in Germany to the extent of producing nitric acid at the rate of 120,000 tons per annum. The guaranteed efficiencies of two of the processes are from 90-95 per cent. An English company (Nitrates, Ltd.), is establishing cyanamid nitric acid factories throughout the allied countries of Europe and guaranteeing an efficiency of 90 per cent. It thus appears that commercially the oxidation of ammonia has proved successful and that it may be considered to be a well-established industry.

Regarding the cost of the process, only one detailed estimate of cost has been encountered in the literature. This is an abstract¹⁶ from the Iron and Coal Trades Review (London) of May 23, 1913, containing a complete estimate of the cost of a small English factory for making nitric acid out of ammonia liquor.

Below is given a revision of this estimate based on American conditions, and considered only from the standpoint of conversion cost, i.e., it is assumed that a supply of pure ammonia gas is already available.

In this estimate it is assumed that there are thirty converters in one building and that in a separate building is the absorption and condensing apparatus, consisting of five absorption towers 60 ft. high. Three coolers and one storage tank are used in supplying acid to each tower. The necessary pans, monteius, compressors, etc., are all included. It is further assumed that each converter unit produces 200 kg. of 36 deg. (53 per cent) nitric acid per day and that the total output per month is 148.4 tons of 53 per cent nitric acid = 78.7 tons HNO_3 = 173,500 lb. HNO_3 .

Plant for conversion (converters).....	\$5,000
Condensing and absorption plant.....	17,500
Foundations for towers and iron work.....	5,000
Acid storage tanks.....	750
Air compressor and motor.....	3,000
Platinum ¹⁷ 1500 g. at \$1.67.....	2,500
Buildings and foundations.....	10,000
Unforeseen outlays.....	3,750
Total.....	\$47,500

The running expenses are:

Power.—For lifting the liquid in the absorber house

¹⁰Metallurgical and Chemical Engineering, 1915, XIII, 218.

¹¹Transaction of the American Electrochemical Society, 1915, XXVII, 385.

¹²Metallurgical and Chemical Engineering, 1916, XIV, 418.

¹³Scientific American Supplement, Sept. 13, 1913, 162.

¹⁴This is equivalent to \$51.80 per troy ounce.

¹⁵Die Chemiker Zeitung, 1915, 848.

¹⁶Scientific American Supplement, Sept. 13, 1913, 162.

¹⁷Journal of the Society of Chemical Industry, 1909, XXVIII, 365.

¹⁸Die Chemiker Zeitung, 1915, 848.

and for direct air pressure, 12 to 15 horsepower, and for running a fan 5 additional horsepower, say 20 horsepower altogether. This means 14,400 horsepower hours per month (30 days) and at 2.5c. per horsepower-hour, the power would cost \$360.

Platinum.—For the whole plant thirty contact elements, weighing 50 grams each are required. The total wear and tear may be estimated at 1.5 grams per day or 45 grams per month. The contact elements can be used a month or six weeks, after which they must be scrapped as old metal and replaced with new. This exchange can be made for about 6 cents per gram. Assuming an exchange once per month, the cost of exchanging the 1455 grams would be \$87.30, and the cost of replacing the 45 grams lost would be \$75.00, a total monthly expenditure for platinum of \$162.30.

Wages.—For superintending and operating valves two men are sufficient per shift; for cleaning, a third man is required (original article). In larger installations it is assumed that these three men could care for twice as much apparatus. Assuming the foreman would get 45 cents, his helper 35 cents, and the cleaner 30 cents per hour, the labor cost would be \$396.00 per month on the three-shift basis. A superintendent at \$150 per month could easily look after a plant four times the size.

The monthly expenditures would then be:

Power	\$360.00
Platinum	162.30
Wages	396.00
Repairs	125.00
Superintendence	37.50
Interest and depreciation at 15 per cent per annum	594.50
	\$1,675.30

This makes the cost of conversion 0.965 cent per pound HNO.

The original investment cost per metric ton of HNO per year is hence \$50.30 for the converting and absorption apparatus and the conversion cost, including interest and depreciation as shown above, is \$21.30 per metric ton. In applying the above figure the cost of the ammonia necessary to make a ton of HNO, would have to be added to the conversion cost. Thus, with ammonia at 7.5 cents per pound the cost of HNO, per metric ton would be, on the basis of an 85 per cent conversion, \$52.50 for NH₃ + \$21.30 for conversion or a total of \$73.80 per metric ton of HNO,. It should be remembered that this is for HNO₃ in the form of 36 deg. Baume or 53 per cent nitric acid.

To see how the above costs compare with the costs obtained by other estimators or with other processes, it might be mentioned that an original investment cost of \$50.20 and a conversion cost of \$23.50 per metric ton of nitric acid per annum were assumed by O. Diefenbach.²⁴ In his estimate he assumed 10 per cent interest on the capital investment. This same calculation gives the cost of concentrating HNO, from 53 per cent to 93 per cent as \$12.43 per metric ton of HNO or 0.563 cent per pound HNO₃.

From another source²⁵ the original investment cost is \$51.90 and the conversion cost is \$28.10 per short ton, which is equivalent to \$57.20 for the original investment and \$31.00 for the conversion cost per metric ton of HNO, as 53 per cent acid. The above estimate and the one in the preceding paragraph, as well as the detailed estimate on page 13, are for small plants. For large plants the article in the *Chemical Trade Journal* gives an original investment cost of \$53.30 per short ton and a conversion cost of \$35.65 per short ton, which is equivalent to \$58.80 for the investment cost and \$39.30 for the conversion cost per metric ton of HNO₃,

as concentrated acid. Some additional figures given in this same article would indicate that the investment cost, when making 53 per cent HNO₃ in large plants, would be \$37.40 and the conversion cost \$21.20 per metric ton of HNO₃. This would give a concentrating cost of \$14.45 per metric ton of HNO₃ or 0.656 cent per pound HNO₃.

Washburn states²⁶ that "roughly speaking and with power at \$10.00 per horsepower year there is to the credit of ammonia from cyanamid about half the cost of weak nitric acid made by the arc process, available for oxidizing the ammonia to nitric acid. The indications are that the cost will not amount to more than half this difference." With power at \$10.00 per horsepower year, a metric ton of HNO₃ made by the arc process and in the form of 53 per cent acid would cost about \$50.00, which, according to the above statement, would make the conversion cost from \$12.00 to \$15.00 per metric ton of HNO₃. This estimate should be regarded conservatively, however, as it is based only on general statements.

Summarizing the above estimates, we obtain the following table in which the figures under (a) refer to small plants and those under (b) to large plants:

Per Metric Ton of 2205 Lbs. of 100 Per Cent HNO ₃	Scientific Amer. Suppl.	Diefenbach	Chem. Trade Journal	Washburn
Investment cost	\$50.30	\$50.20	(a) \$57.20 (b) \$37.40	.....
Conversion cost to 53 per cent acid	21.30	23.50	(a) 21.20 (b) 14.45	\$12-\$15
Concentrating cost to 93 per cent acid .....	.....	12.43	(a) 14.45 (b) 39.30	.....
Conversion cost to 93 per cent acid per lb. 100 per cent HNO ₃ .....	.....	35.93	(b) 39.30	.....
		1.632c. (b)	1.583c.	.....

There is a fair amount of agreement among the first three estimates, but the estimate of Washburn is so much lower that it should be regarded with reserve, especially when it is considered that it is only a general statement upon which the estimate is based. On the other hand, it must be remembered that this process has made immense advances in Germany very recently, and as Washburn's statement was made at least a year later than the appearance of the other estimates, it is quite likely that this process can be carried out more cheaply than the older estimates would indicate.

The true figure probably lies somewhere between the two, i.e., the conversion cost is probably about \$18 per metric ton of HNO₃ in the form of 53 per cent acid, or 0.816 cent per pound HNO₃. To this must be added the cost of the ammonia and the cost of concentrating the acid to 93 per cent. Even with ammonia at 5 cents per pound and a conversion of 85 per cent, the ammonia would cost 1.587 cent per pound HNO₃, and the concentrating cost would hardly be less than 0.375 cent; so that HNO₃ in the form of 93 per cent acid, could hardly cost less than 2.778 cents per pound by the Ostwald process.

The question of the profitability of the Ostwald process, on the basis of the above figures, depends on several considerations. The price of ammonia is governed by the price of sodium nitrate, the prices of these two substances always being approximately equal when calculated to a basis of their nitrogen content. If it costs less to convert ammonia to nitric acid than it does to convert soda to nitric acid, it will naturally be more profitable to use the Ostwald process than the present process. In this conversion the cost of sulphuric acid must be included in the latter process. But, consideration must also be given the fact that the yields with the two processes are different, that with the Ost-

²⁴Transactions American Electrochemical Society, 1915, XXVII, 385.

²⁵This becomes \$58.80 when the concentrating apparatus is included.

²⁶Chemische Industrie, 1914, 265.

²⁷Chemical Trade Journal and Chemical Engineer, 1914, 283.

wald being usually taken as 85 per cent, that with the present process at 97 per cent. Therefore, in order to break even and with equal cost of nitrogen in the raw products, the Ostwald process must be capable of converting its raw product into nitric acid more cheaply than the present process in order to take care of the greater amount of nitrogen lost in the conversion, and the difference in conversion costs must hence be greater the higher the initial cost of the nitrogen.

The cost of conversion by the Ostwald process, 93 per cent nitric acid being the end product, we have seen could hardly be less than 1.191 cent per pound HNO_3 . The cost of nitric acid made from nitrate of soda is probably at least 1.75 cents per pound for labor, repairs, etc., and sulphuric acid. The cost for nitrogen, with nitrate of soda at 2.64 cents per pound, would be 3.750 cents for the retort method and $97 \div 85$ of this or 4.280 cents for the Ostwald process per pound HNO_3 . These figures are arrived at by assuming that 1.42 lb. of nitrate of soda are used per pound 100 per cent HNO_3 , which is about the case with a yield of 97 per cent; $1.42 \times 2.64 = 3.75$ and $97 \div 85$ of $3.75 = 4.28$ cents. If nitrate of soda should fall to 1.5 cent per pound, below which it is hardly conceivable it could ever go, the nitrogen cost per pound HNO_3 would be $1.42 \times 1.5 = 2.13$ cents for the retort process and $97 \div 85 \times 2.13 = 2.43$ cents for the Ostwald process.

We would then have:

	Ostwald	Retort
Nitrate of soda at 2.64c., NH_3 at 13 $\frac{3}{4}$ c.		
Cost of conversion.....	1.191	1.750
Nitrogen cost.....	4.280	3.750
Total cost.....	5.471	5.500
Nitrate of soda at 1.5c., NH_3 at 7.5c.		
Cost of conversion.....	1.191	1.750
Nitrogen cost.....	2.430	2.130
Total cost.....	3.621	3.880

From these figures it can be seen that with the present price of nitrate of soda the Ostwald process can make nitric acid for only a fraction of a per cent less than the retort process. If the price of nitrate of soda decreases, however, and with it the price of ammonia, the Ostwald process becomes increasingly more profitable. With nitrate of soda at 1.5 cent per pound the cost of the Ostwald process for making nitric acid would be 93 per cent of the cost of making it by the retort process.

It is a little difficult, at first, to see why the Ostwald process should not be profitable now, using by-product ammonia, which can certainly be produced for less than 13 $\frac{3}{4}$ cents, the ammonia price corresponding to a nitrate of soda price of 2.64 cents per pound. A little consideration will show, however, that it is much more to the producer's advantage to sell his by-product ammonia for 13 $\frac{3}{4}$ cents than to convert it into nitric acid to be sold at only a very slight advance over this price.

It is also a little difficult to see why the Ostwald process should be increasingly more profitable as the nitrate of soda price falls. The reason is that as the nitrate of soda price falls the ammonia price falls correspondingly. The conversion cost remains the same with both processes, however, being approximately a half cent per pound of HNO_3 higher with the retort process. At the present price of nitrate of soda this difference is neutralized by the larger amount of raw material needed by the Ostwald process on account of its lower conversion yield. As the cost of the raw material falls, however, the raw material makes up an increasingly smaller proportion of the total cost, so that the higher conversion cost of the retort process begins to influence more and more the total cost.

The figures obtained in the foregoing estimate do

not agree very well with the statement of Washburn* that the cost of making nitric acid from ammonia in Europe at the present time is about 70 per cent of the cost of making it from soda, even though his statement is based on a 90 per cent conversion for the contact process. Of course, it is unknown whether the above statement refers to normal conditions in Europe, or the present abnormal ones.

Regarding the advantages and disadvantages of the Ostwald process, they seem to sum up as follows:

Advantages.—The process is continuous, which makes for a maximum return from the investment. It is capable of installation in small units, which makes for flexibility in operation. The exit gases from the converters are several times as concentrated as those from any arc furnace, which allows of enormously cutting down the size of the absorption apparatus. The raw product, ammonia, is easily obtainable in the United States, making us independent of foreign supplies in case of war. The power costs are very low, hence the plant could be located almost anywhere.

Disadvantages.—It is only a step and not a complete process, hence the plant would have to be located with respect to economy of freight on incoming supplies, either cyanamid or ammonia liquor. It is hardly profitable unless the cost of ammonia drops to a figure that is improbably low.

Conclusion.—So far as information is available it would hence appear that the Ostwald process, and this term is meant to include all processes of the catalytic oxidation of ammonia, is hardly in a position to compete with even the present process of manufacturing nitric acid from nitrate of soda. Even with a considerable reduction in the price of ammonia the possible profit is so small and the reliability of the figures on which the cost estimates are based is so problematical that it would seem a rather doubtful proposition to entertain.

It should be remembered that the foregoing reasoning is based on a yield of only 85 per cent for the Ostwald process. If it could be possible, for example, to raise the yield to 97 per cent, the yield usually obtained by the retort process, the Ostwald process could produce nitric acid for about a half cent per pound less than the retort process. There is no general information available at present, however, which would indicate that the conversion efficiency of the Ostwald process is much in excess of the 85 per cent used throughout this paper.

When it comes to comparing the cost of nitric acid made by the Ostwald process with the cost of nitric acid made by the arc process, relatively accurate figures for which are available in the literature, the cost by the Ostwald process is seen to be so high that there is little use giving it further consideration.

It should be emphasized again, however, that due to the secrecy observed in the country where the process was evolved, with respect to making public the details of the process, the information obtained from the literature cannot be credited to too great an extent. This information is the best we have at hand, however, at the present time. After the cessation of hostilities in Europe it may come to light that the Germans have perfected and cheapened this process to such an extent that it might prove worth considering, for installation in small units at isolated points. It seems very unlikely, however, that it can ever be cheapened to an extent where it can compete on the large scale with nitric acid by the arc process, unless a much better yield of ammonia can be obtained than seems to be the case at the present time. Ammonia will always be too valuable *per se*, to consider making cyanamid, how-

*Metallurgical & Chemical Engineering, 1916, XIV, 138.

ever cheaply, for the sole purpose of converting it to nitric acid.

There is appended a bibliography which collects the references given throughout the text, and in addition gives several other references which were not directly referred to. Some of these are only short notices, others long articles giving much detailed and general information, but all have a bearing on the process under consideration. This list is not by any means complete, but the compiler believes that no important reference in any of the more well-known journals has been overlooked.

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68, 155, 179, 239, 288; 1915, LV, 45, 553; 1915, LVII, 28.

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Zeitschrift für Angewandte Chemie, 1914, I, 48.

Metallurgical and Chemical Engineering, 1906, 137; 1913, 438.

476, 714; 1915, 213, 218, 241, 314, 325, 620; 1916, 418, 513. (Until the end of 1909 this journal was known as "Electrochemical and Metallurgical Industry.")

ADDENDUM

Since the above article was written two patents have appeared (U. S. 1,193,796 and 1,193,797) which might be construed to alter somewhat the reasoning expressed in the conclusions. These patents deal with the oxidation of ammonia and claim to obtain a 95 per cent conversion. Their novelty lies in the cooling of the ammonia-air mixture up until the very time it comes in contact with the hot catalyser, in distinction to the principle of heat exchange mentioned in Ostwald's original U. S. patent. Because no heat is carried to the catalyser by the gases it must be heated in some other manner, preferably electrically.

As the claim that a 95 per cent conversion can be obtained appears only in a patent specification and has not yet been substantiated, so far as any information available in the literature would indicate, it would seem as yet a little too early to assume that these patents have any serious bearing on this problem. Later developments may show them to be of great importance, but time will be required to prove this.

Western Metallurgical Field

Company Reports

Inspiration Copper Company's report for the year 1915 states that copper production began in June, 1915, the first unit of the new mill going into operation on June 29. During the last six months of the year copper production amounted to 20,445,670 lb., of which 20,067,310 lb. was recovered from 778,851 tons of ore concentrated and 378,360 lb. from oxide ore shipped to smelter. The ore averaged 1.7 per cent copper, of which 0.226 per cent was in oxidized form. Tailings assayed 0.373 per cent copper, of which 0.18 per cent was oxidized. Flotation concentrates averaged 37.63 per cent copper, and table concentrates 13.12 per cent. The average assay of all concentrates made was 32.67 per cent copper, and the percentage recovery of all copper was 79.95. Average percentage

recovery of sulphide copper was 88.56. Ratio of concentration was 24.6:1. The following tabulation of costs is given for the treatment of 778,851 tons of ore, producing 20,067,310 lb. copper.

	Per Lb. Copper	Per Ton Ore
Mining	2.644c	\$0.68110
Coarse crushing	0.113	.02910
Ore hauling	0.079	.02025
Concentrating and royalty	1.389	.48675
Concentrate hauling	0.006	.00160
	4.731c	\$1.21880
Smelting, freight, refining, marketing, etc.	3.455	.76420
	8.136c	\$1.98300

The saving of sulphide mineral by flotation has improved since the mill first went into commission and has not only exceeded the expectations of a year ago, but is now better than the average for 1915. For the month of February, 1916, the saving of sulphide copper was 91.1 per cent. Coal tar continues to be used as the chief component of the flotation-oil mixture. An interesting item in connection with the test mill is that it treated 373,705 tons of ore and paid for its cost of construction, operating expense, the present average cost of mining on ore treated, and left something besides. The cost per ton of daily capacity for the equipment of the property to mine and mill 14,400 tons daily is given as \$833, of which \$625 was for equipment of mine and mill, water supply, power, mill site, tailing land, railroad, etc., and \$208 for advanced mining expenditures to prepare for an output of 14,400 tons per day. Operating costs for mining and milling at Inspiration probably will range from \$1 to \$1.15 per ton of ore.

The annual report of the Hollinger Gold Mines, Ltd., is accompanied by a report recommending consolidation of the Hollinger property with those of the Acme Gold Mines, Ltd., Millerton Gold Mines, Ltd., and Claim No. 13,147 of the Canadian Mining & Finance Co., Ltd. During 1915 Hollinger produced gold bullion of the value of \$3,169,814, an increase of \$480,459 over the previous year, in spite of the lower grade of ore treated, the comparative values per ton being \$13.67 in 1914 and \$10.11 in 1915. Net profits amounted to \$1,916,467, from which dividends of 52 per cent were paid amounting to \$1,560,000. The surplus now amounts to \$1,478,210. The summary of ore reserves shows a gross value Dec. 31, 1915, amounting to \$16,031,600, nearly three million dollars greater than a year previous. The milling record shows the treatment of 441,286 tons of ore, of which 334,705 tons came from the Hollinger and the balance from the Acme. Detailed information on the treatment of the Hollinger ore follows: Average value per ton \$10.11; average daily tonnage, 917; stamp duty per 24 hr. running time, 14.72 tons; value per ton of tailings, 40 cents; cyanide consumption per ton of ore, 0.574 lb.; zinc consumption, 0.467; tons solution precipitated per ton ore, 1.909; zinc added per ton solution, 0.244 lb.; average value pregnant solution, \$5.074. The cost of milling the Hollinger ore was \$0.999 per ton. Concentrates have been stored for treatment, amounting to 9500 tons with a gross gold value of \$81,763. This material will now be reclaimed as rapidly as possible. Costs for 1916 are expected to increase owing to the advance in cost of supplies, ranging from 10 per cent to 500 per cent.

Steady Demand for Ferromanganese.—There is a steady inquiry for prompt ferromanganese. Foreign material is quoted at \$175 per ton at seaboard. Domestic ferromanganese is quoted at \$170, with some "electrolytic" offered at \$165 per ton.

The Metal Tie-Up in Electrolytic Refining

BY LAWRENCE ADDICKS

Most electrolytic refining processes have to compete with fire processes which are as a rule less satisfactory technically, but which turn out the product in a very much shorter time. This slow turn-over imposes heavy interest charges on account of the large investment in plant which it implies and from the necessity of financing the metals in process. The plant investment and the amount of metals locked up are closely related to the current density employed, but as the power required increases nearly as the square of the current density, a point is soon reached where the cure is worse than the disease.

TABLE I

Metal	Normal Market Value Dollars per lb.	Electrochemical Equivalent Grams per Ampere-hour	Quotient X 104
Iron	0.01	1.04	1
Lead	0.04	3.86	1
Zinc	0.06	1.22	3
Copper	0.15	1.19	13
Nickel	0.30	1.09	29
Silver	9.00	4.03	232
Gold	300.00	2.45	12700

The case varies greatly with the metal under consideration, depending upon its electrochemical equivalent and market value. Some idea of this variation can be obtained from an inspection of Table I, which takes the ratio of these two factors as a measure of the relative costs. Although this table is inexact in that it ignores voltage and other minor factors it shows how in the case of lead a handicap has been removed enabling electrolysis to compete with the best of fire processes, while gold is electrolyzed in but few plants not under Government auspices, where locked values are not of any importance.

The question is somewhat complicated by the fact that the bullion being electrolyzed is generally a mixture of two or more metals, each of which is to be recovered. The refining of blister copper carrying silver and gold will serve as an example upon which to base further discussion of the problem.

Copper refining contracts specify certain permissible elapsed times for the return of or payment for the values in the bullion to be refined, varying from 45 to 75 days for the copper and from 60 to 90 days for the silver and gold. It is evident that the earlier the metals can be put on the market the sooner their cash value can be put to earning money elsewhere and, therefore, that each day that the process locks up the values has a definite cash value. This is not greater than 6 per cent, however, as the banks consider warehouse certificates based on metals in process satisfactory collateral for loans up to a high percentage of their market value in ordinary times. Taking copper at fifteen cents a pound, the interest value of a sixty-day refining allowance is three dollars a ton, and each ton-day costs five cents, with corresponding values for the silver and gold contents. The cost of refining is made up of operating expenses, metal losses and metal interest, and it is the purpose of this article to examine the last.

Metals are tied up in process for three quite different reasons which might be stated as commercial, technical, and balancing. Commercial policy makes it desirable to hold incoming bullion at times before putting it into process until certain conditions are fulfilled, such as agreement of assays, or such a state of weather as shall obviate the necessity of moisture allowance when weighing; or fluctuations in the metal market may make it advantageous to go to extra operating costs to cut down what normally would be considered proper stocks in

process or delay the purchase of metals lost in process; finally it is good policy to endeavor to carry reasonable stocks of refined shapes on hand so as to be able to adjust shipments to unexpected changes in orders, steamer sailings and the like. It is quite reasonable to have 10 per cent of the total tie-up in copper due to such causes.

Then we have the values locked up for technical reasons which may be classified as metals truly in active process, metals circulating in slags, etc., metals permanently tied up in furnace bottoms, etc., and metals forever lost to be charged into operating costs as metal losses.

Finally there are the stocks of pig, anodes and cathodes which it is necessary to carry in order to insure smooth, continuous operation regardless of minor irregularities in arrival of pig or breakdowns in some parts of the process. To these the name of "balancing" metals has been given for want of a better term.

The total metals tied up are, of course, shown by the balances due customers on the metal books of the plant, but these figures give no data of value in the analysis or control of the values. It is also customary to take annual physical inventories of metals on hand in order to determine accurately the metal losses for the preceding year. This indicates the metal tied up in each part of the plant but unfortunately in order to take a proper inventory without shutting down the process it is necessary to introduce temporarily radical changes in operation which greatly increase the tie-up. It is, therefore, necessary to rely upon a thorough understanding of the sources of locked values and of their relative importance and a constant scrutiny of conditions in order to control this important factor in the total cost of operating a copper refinery.

CLASSIFICATION

Fig. 1 gives a systematic classification of the sources of locked values which we shall proceed to take up item by item. The items under the heading "Commercial" may be dismissed with the arbitrary assumption of five days delay of copper, four days of silver and three days gold.

METAL IN PROCESS

Turning next to the delays for technical reasons and taking first "metals in process," Fig. 2 gives the direct course of the metals through the process ignoring all diversions.

The weighing, sampling, and handling of pig to the anode furnace properly occupies one day. The refining and casting into anodes is a twenty-four hour operation. In the tank house conditions vary greatly in different plants, but representative eastern practice may be taken as 14 days cathodes and 28 days anodes, making an average age of 21 days for the two sets of electrodes. The refining furnace is operated on the same basis as the anode furnace, calling for one day. Certain parts of the plant are shut down on Sundays, but this is assumed to have no effect upon the final date of delivery of refined copper.

In the silver refinery the length of time required to recover doré from the slimes will depend greatly upon the impurities present, but it is not likely to be less than three days for dissolving the copper in the slimes and six days for furnacing them.

In the parting plant, assuming electrolytic parting is used, the anodes will probably last three days and the cathode crystals be cleaned up every few hours, making an average of one and a half days. The washing and melting of the silver sponge takes but a few hours, say half a day. The gold mud would be cleaned every three days and the boiling and melting take two days.

We can now sum up the time required as shown in Table II.

TABLE II

	Copper	Silver	Gold
Weighing and sampling.....	1	—	1
Anode furnaces.....	1	1	1
Tank house.....	21	21	21
Refining furnaces.....	1	—	—
Boiling slimes.....	—	3	3
Furnacing slimes.....	—	6	6
Parting dore.....	—	1.5	3
Melting silver.....	—	0.5	—
Refining gold.....	—	—	1.5
Melting gold.....	—	—	0.5
Total days.....	24	34	37

These figures show first that but about half the time allowed for refining is required by a straight passage through the process, thereby giving the goal we should strive to approach, and second that as would be expected the slow item is the electrolysis. This time can be lessened by cutting down the age of the anodes or of the cathodes or of both. Too light an anode increases handling costs and the percentage of anode scrap made, while too light a cathode runs up disproportionate charges for making starting sheets and decreases the productive hours of the tanks, which have to be cut out while drawing copper. As before stated the power

charges mount very rapidly with increasing current density.

METALS CIRCULATING

The sample diagram shown in Fig. 2 would become an almost undecipherable confusion of lines were it expanded to indicate every movement of circulating metals. As we proceed from pig to cathode a fraction is diverted at each stage of the process and sent back to an earlier one.

Each of the furnace processes may be illustrated by the first diagram in Fig. 3 and both the copper electrolysis and the doré parting by the second except that there are no starting sheets in electrolytic parting processes, the silver being deposited in non-adherent crystals upon a fixed carbon or silver cathode.

The return arrows indicate circulating metals and the straight ones metals locked up continuously. The two cases are alike in their effect upon the process except that the former varies directly with the output while the latter are more or less constant for a given plant regardless of output. (Metals actually lost are a third case, but the quantities involved are small and are generally adjusted by systematic purchases so as to have but a negligible effect upon the time required for refining and they will be ignored in this article). Liquors partake of both characteristics, as a certain stock is

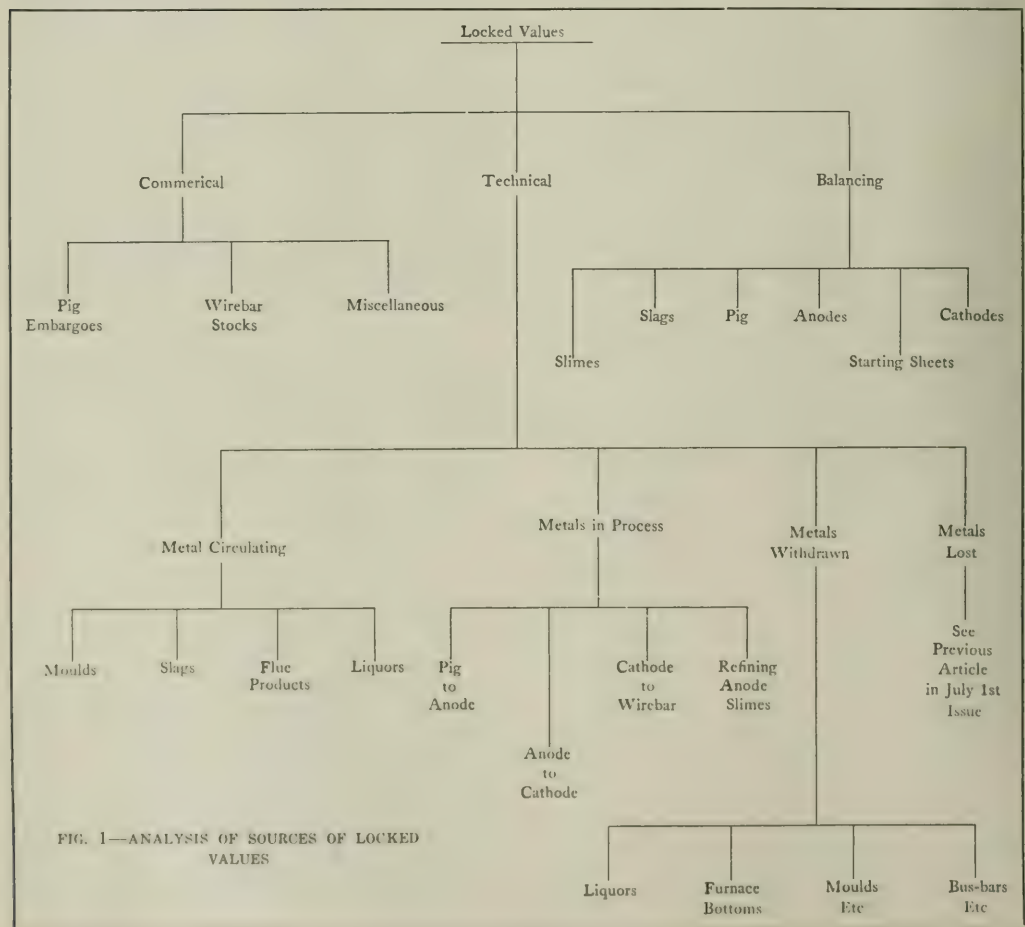


FIG. 1—ANALYSIS OF SOURCES OF LOCKED VALUES

required for starting up the plant while another quantity circulates through the purifying departments, etc.

Returning to the plan laid down in Fig. 1 we shall consider the metals circulating in slags, flue-products and liquors.

ANODE FURNACES

The first and simplest case is that presented by the anode furnaces; first because, if we ignore the small amount of values circulating in the drillings from sampling, the anode furnaces divert the first fraction from the entering pig, and simplest, because the slag and flue products have made return directly to the anode furnaces themselves after being reduced to pig in a cupola, giving a single fraction to consider.

The quantity of slag made by an anode furnace varies with the purity of the pig from less than 1 per cent of the charge to several per cent. The slag itself will run from 35 to 45 per cent copper and the silver and gold slagged will be proportionately less than the copper. We shall assume that we have made 1.5 per cent of the copper contents of charge in slag running 40 per cent copper and that the silver and gold slagging ratio is 0.85 and 0.45 respectively, with copper at 1.00. In flue dust we shall recover about 0.07 per cent of the copper and say 0.1 per cent of the silver and 0.05 per cent of the gold treated. Then we have other flue products such as the cobbing from repairs, and the quantity of this also varies greatly with the character of the bullion under treatment. We shall assume it to amount to 25 per cent of the metals in the slag. Then there is a negligible amount of bad production, scale, etc., charged back next day. We have therefore as a measure of the apparent shrinkage of the values in process, ignoring actual metal losses, the figures given in Table III.

TABLE III

Anode furnace diversions	Copper	Silver	Gold
Charged to furnace.....	1.0000	1.0000	1.0000
Slag contents.....	0.0060	0.0051	0.0027
Flue dust.....	0.0007	0.0010	0.0005
Cobbing, etc.....	0.0015	0.0013	0.0007
Total diversions.....	0.0082	0.0074	0.0039
Net output.....	0.9918	0.9926	0.9961

The actual retreatment of these by-products does not take over a day, the process being simply reduction to big copper in a small cupola. In practice a great deal of time is lost in storage before retreatment, but this will be taken up later under "balancing" the process.

TANK HOUSE

The tank house has three circulating items; anode scrap, starting sheets, and liquors.

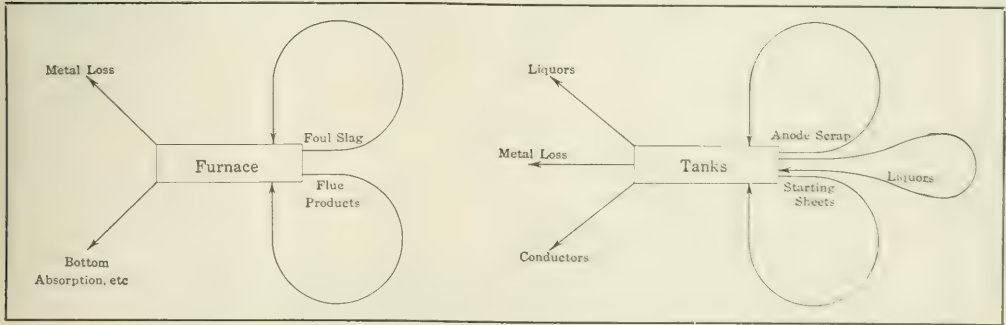


FIG. 3—TYPICAL METAL MOVEMENTS

Anode scrap is the part of an anode remaining after it has been eaten away by the current until but a skeleton remains hanging from the supporting lugs. These lugs generally account for from 3 to 5 per cent of the total weight of the anode and this percentage represents the lowest possible anode scrap.

In practice the scrap made varies between 7 and 20

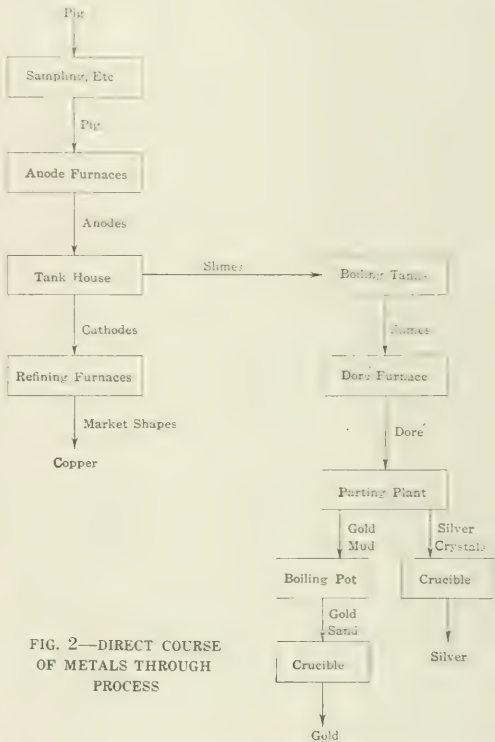


FIG. 2—DIRECT COURSE OF METALS THROUGH PROCESS

per cent. A poorly refined anode will dissolve unevenly and cause heavy scrap, while careful filling of the "holes" caused by drawing individual anodes which work out first will lessen the final scrap made. The best policy, however, is to refine the anodes thoroughly and take no chances on disturbed current distribution in the tanks due to "lace" anodes, so that a normal percentage of scrap will be about 14 per cent of the weight of the anodes charged. This scrap is subject to a charge

of 28 days in the tank house plus the time required for the anode cycle.

The starting sheets are cathodes which are deposited upon greased copper plates and stripped as a thin sheet when they are about twenty-four hours old. They are used as mother sheets upon which they build up the cathodes proper. As the cathodes are drawn in fourteen days, one twenty-eighth of the number of tanks (each copper plate or "starting blank" yields two starting sheets) must be turned over to this service. Actually a little more than this is required for the manufacture of loops by which to hang the cathodes and to allow for bad sheets. The production of bad sheets will be considered negligible and one twenty-fifth, or 4 per cent, of the output will be considered to be in starting sheets which have been set back two days, one day depositing and one for attaching loops, etc., by this diversion.

The copper tied up in the electrolyte comes chiefly under the head of "metals withdrawn," but a certain amount circulates between the tank house and the silver building and the tank house and the purifying department. The first of these is a small item. The slimes are pumped over to the silver building as a soup carrying perhaps 5 per cent solids, but as the slimes amount to but about one and a quarter per cent of the anodes and as the electrolyte carries but 3 per cent copper, the total copper involved in the movement is but three quarters of a per cent of the anode weight. The slimes are settled out and the liquor returned in about twenty-four hours.

The proportion of liquor required for purifying depends, of course, upon the impurities present in the anode. In the first place there is a certain amount of copper dissolved chemically from the electrodes which would cause an accumulation of copper in the electrolyte were there no compensating factors. If the anodes are very free from impurities, insoluble anode tanks must be operated to recover about 2 per cent of the cathode output in order to strike a balance.

On the other hand if nickel is present in the anodes this dissolves electrochemically but is not deposited at the cathode, so that if much is met with a condition of actual insufficiency of copper in the electrolyte may obtain, calling for the use of shot towers.

Antimony may be precipitated chemically as oxychloride and arsenic electrolytically in the insoluble anode tanks. Iron should be adequately removed in the anode furnaces. Nickel, however, accumulates and must be removed by evaporating liquors.

It will thus be seen that quite different conditions may exist at different plants or at the same plant at different times. For our case we may assume that the equivalent of 1 per cent of the copper in the anode has to be regularly removed. Practically all of the copper contents of this solution will be eliminated in the three successive sets of insoluble anode tanks

from the silver building. This amounts to about 0.20 per cent of the copper in process, or say 0.17 per cent of the anode weight. It is returned to the tank house as copper sulphate and has about a ten-day cycle.

Summarizing, we have for a unit of anode copper entering the tank house the diversions given in Table IV.

REFINING FURNACES

The refining furnaces are similar to the anode furnaces as regards circulating metals except in that the quantity of by-products made is smaller owing to the practical absence of impurities and that a handicap exists owing to the necessity of sending these back through the cupola to the very beginning of the process. The values assumed for the anode furnace may be scaled down as given in Table V.

The bad production consists of defective castings which are charged back into the furnace next day. The

TABLE V		
Diversions from Refining Furnace	Copper	Route
Charged to furnace.....	1.0000	
Slag	0.0030	Cupola
Flue dust	0.0001	Cupola
Cobbing	0.0010	Cupola
Bad production	0.0100	Refining furnace
Moulds	0.0200	Refining furnace
Total diversions.....	0.0341	
Net production.....	0.9659	

molds may be considered also as returned next day, the balance of the period by their use being considered under "metals withdrawn." We are assuming that the anode furnaces use cast iron and not refined copper molds. The small amounts of silver in gold in the refining furnace by-products are ignored.

SILVER REFINERY

We come next to the silver refinery. The anode slimes carry all the silver and gold, neglecting losses, and about 0.2 per cent of the copper, as already stated. For

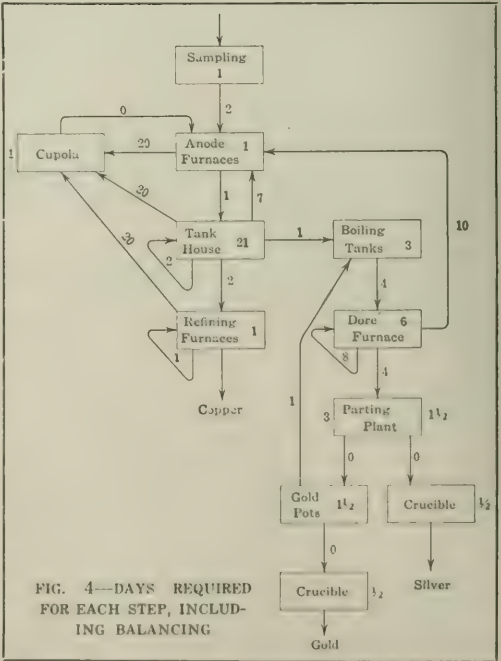


FIG. 4—DAYS REQUIRED FOR EACH STEP, INCLUDING BALANCING

TABLE IV		
Diversions from Tank House	Copper	Route
Entering.....	1.0000	
Anode scrap.....	0.1100	Anode furnaces
Starting sheets.....	0.0100	Tank house
Copper in slimes.....	0.0017	Tank house
Electrolyte to silver building.....	0.0075	Tank house
Electrolyte to purifiers.....	0.0100	Cupola
Total diversions.....	0.1992	
Net output.....	0.8008	

through which it will be passed as a first stage in the purification and we need not follow this further. We may assume that these tanks will be cleaned once in ten days and the product sent to the cupola.

Then we have the copper in the anode slimes returned

our purposes the small amount of copper entering the doré furnaces may be neglected.

The next step in the treatment of the slimes is a reverberatory smelting. The slimes are melted and tend to form three distinct layers, bullion, matte, and slag. The slag is skimmed off and the matte, if small in quantity, as it should be if the copper has been properly removed in the slimes boiling tanks, broken up by blow-

ing. The foul bullion is then refined to high-grade doré by cupeling without the addition of lead. The final by-products are two slags, flue dust and cobbing, all of which, after sorting out metallics, are sent to the anode furnace. We shall assume the data stated in Table VI.

The doré is sent to the electrolytic parting plant, but as there is neither anode scrap, nor starting sheets, assuming the Thum-Balbach system with horizontal electrodes is employed, the only circulating values are in the wash waters from the crystal silver and these are so small that they may be neglected here. The same is true of the slags from the crucible melting of the gold and silver.

There is, however, some circulating silver from the refining of the gold anode mud. This mud may be considered half gold and half silver, so a quantity of silver just equal to the gold output is dissolved in the boiling kettles and sent back to the slimes boiling tanks. As we have assumed slimes with 12,000 oz. per ton of silver and 100 oz. per ton of gold this represents a diversion of 0.0083 or a net output of 0.9917.

	Weight	Assay—Ozs per ton	Silver	Gold
Slimes	2600	12,000	100	
Poor slag	200	800	1	
Rich slag	500	1,200	6	
Flue dust	200	1,200	1	
Cobbing	40	1,200	6	

We can now build up a schedule for the reverberatory doré furnace. This is given in Table VII.

	Silver	Gold	Route
Charged to furnace	1.0000	1.0000	
Rich slag	0.0250	0.0150	Doré furnace
Poor slag	0.0100	0.0015	Anode furnace
Flue dust	0.0100	0.0010	Doré furnace
Cobbing	0.0020	0.0012	Anode furnace
Total diversions	0.0470	0.0187	
Net output	0.9530	0.9813	

SUMMARY OF CIRCULATING METALS

We are now in a position to revise Table II by the application of the diversion factors for circulating metals in order to show what proportion of the metals entering the process emerge directly in the period given

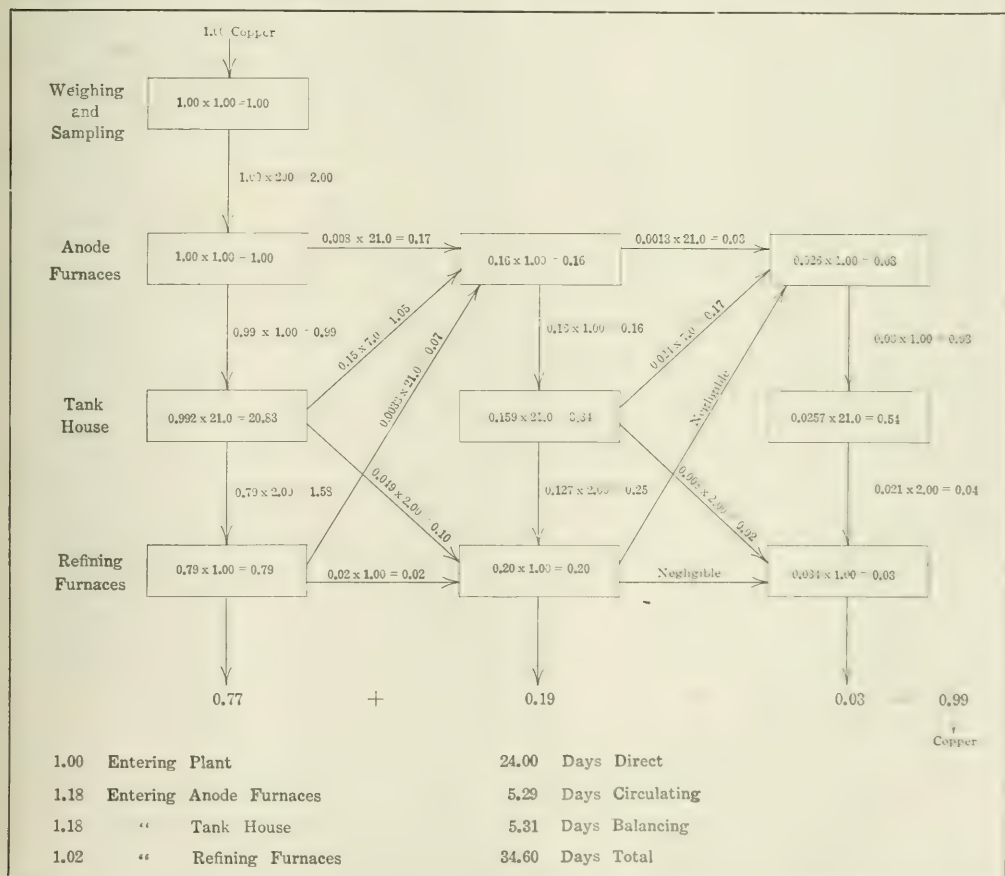


FIG. 5—COPPER

in that table. This summary of diversions is given in Table VIII.

TABLE VIII
Summary of Diversions

	Copper		Silver		Gold	
	Factor	Cumu-	Factor	Cumu-	Factor	Cumu-
	lative	lative	lative	lative	lative	lative
Weighing and sampling.....	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Anode furnaces.....	0.9918	0.9918	0.9926	0.9926	0.9961	0.9961
Tank house.....	0.8008	0.7942	0.8600	0.8556	0.8600	0.8566
Refining furnaces.....	0.8693	0.7671	0.9530	0.8154	0.9813	0.8406
Furnacing slimes.....	.....	.....	1.0000	0.8154	1.0000	0.8406
Parting Doré.....	.....	.....	1.0000	0.8154	1.0000	0.8406
Melting silver.....	.....	.....	0.9917	0.8086	1.0000	0.8406
Refining gold.....	.....	.....	1.0000	0.8086	1.0000	0.8406
Melting gold.....	.....	.....	.....	.....	.....	.....
Net product.....	0.7671	.....	0.8086	.....	0.8406	.....

The figures of Table 8 show that but 77 per cent of the copper, 81 per cent of the silver, and 84 per cent of the gold entering the plant go directly through the process in the 24, 34, and 37 days shown by Table 2, the balance being diverted into by-products which require retreatment. The result of this is that the actual metals in process of treatment at various stages is greater than the pig receipts or cathode output by the amount of these circulating metals. It is also obvious that as these retreated metals start through the process a second time a portion is again diverted. There are several ways of evaluating this, the simplest of which is probably to work out several terms of a continued fraction, thereby ascertaining the total metals passing through each step of the process.

BALANCING METALS

In order to get the time element we must consider the "balancing metals," or stocks held at various points in the process in order to insure continuity of operation

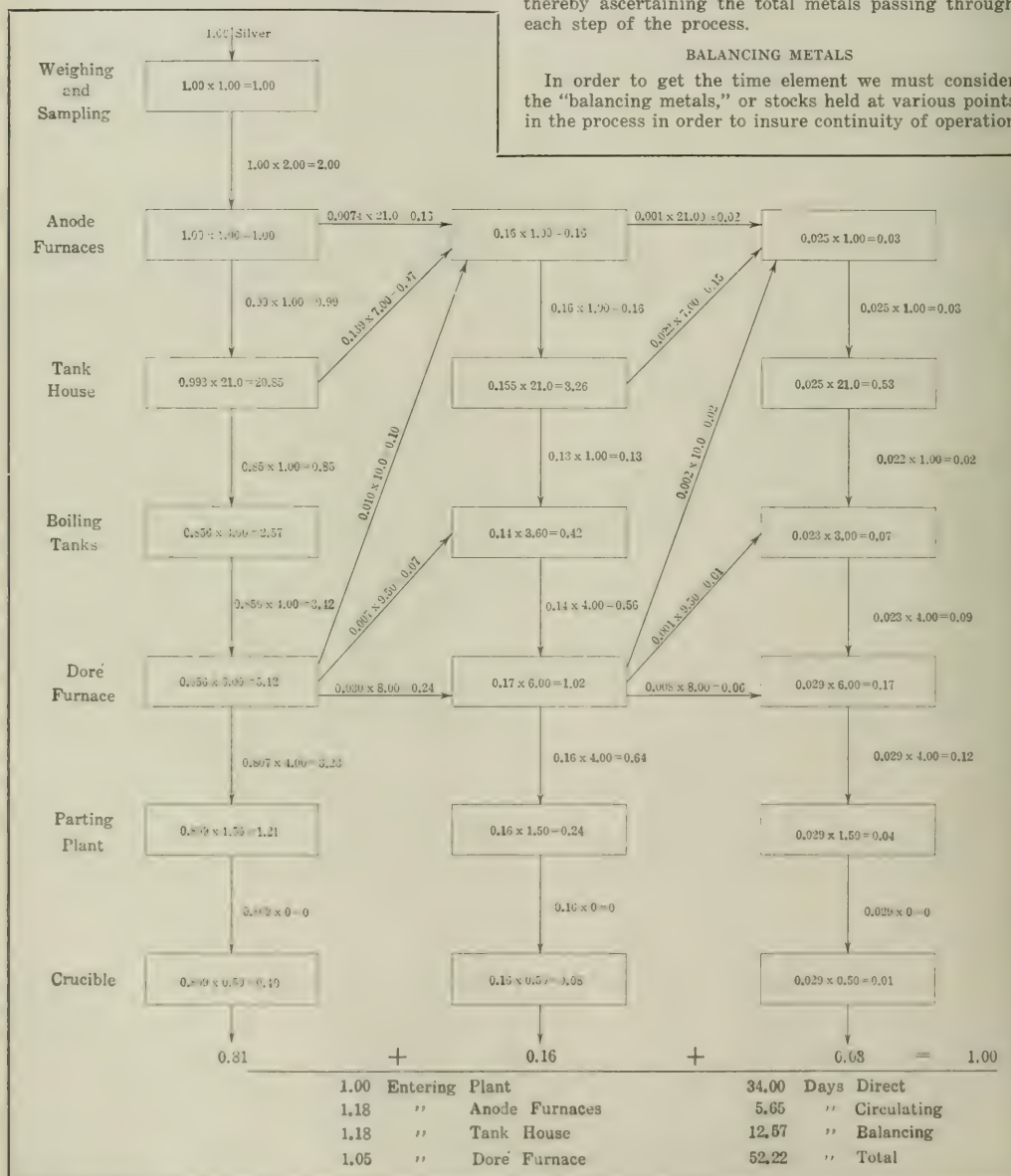


FIG. 6—SILVER

without disproportionate cost. This is done graphically in Fig. 4, where the numbers represent days. Where they occur between the rectangles representing steps in the process they stand for the average number of days

output at that point held in stock; where they occur inside or alongside the rectangles they represent the days in process shown by Table 2.

We can now proceed to construct the diagrams showing the unit-days lost at each step and this has been done separately for the copper, silver and gold in Figs. 5, 6, and 7. Each vertical row in these figures represents one term of the continued fraction. Three terms are sufficient to approximate the total. In order to simplify the diagram the cupola has been omitted, although allowed for in the days given, and some items

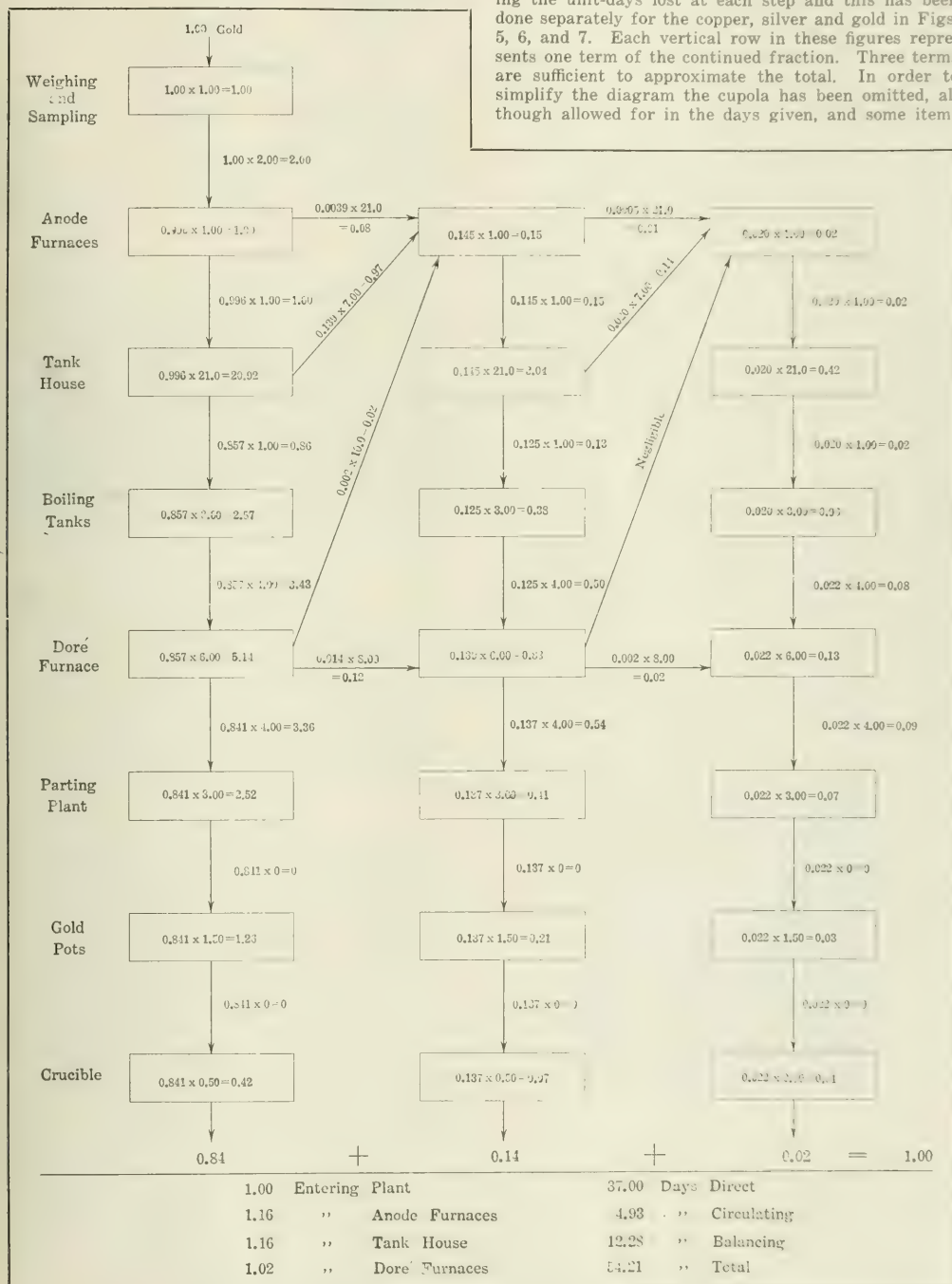


FIG. 7—GOLD

have been averaged in groups. The figures are units of weight times days equals unit-days, and as one unit of weight is shown entering the process the sum of the unit-days is the actual total days that unit is in process.

METAL WITHDRAWN

We have finally to consider the "metals withdrawn" by liquors, furnace bottoms, conductors, and molds. These are easily translated into unit-days by considering how long the plant would have to run in order to fill these storage vaults.

LIQUORS

We have two main bodies of liquor to consider, the copper sulphate electrolyte in the tank house and the silver nitrate electrolyte in the parting plant, the latter carrying negligible amounts of copper, however.

In the tank house in addition to the liquor actually in the tanks there is a large additional quantity in the piping system and sumps. In general in a large plant there is required about 20 lb. of liquor per pound per day of copper treated. As the electrolyte runs about 3 per cent in copper this is equivalent to saying that 0.6 days output of the plant will be required to stock up the electrolyte.

In the parting plant this factor is a little less, say 0.4 day, as there is not the circulating system to allow for.

FURNACE BOTTOMS

There are four main furnace bottom absorptions, anode, refining, cupola, and doré. The anode and refining furnaces are alike except that 18 per cent more capacity is required in the anode department as shown in Fig. 5, and that the refining furnace ties up no silver and gold. An anode furnace will absorb from 100 to 400 lb. of copper per square foot of hearth area, depending upon the age, thickness and composition of the bottom.

It is customary to start the soaking of a new bottom with material lean in silver and gold and in general the relative absorption of silver is lower than the amount to be expected from the grade of bullion treated; this ratio changes with age, however, and gold in particular seems to concentrate in the bottom.

For our purpose we may assume 0.40 days copper for the complete absorption of the furnace and flues of a refining unit. This will become 0.47 days for an anode furnace. The silver will be say 0.25 and gold 0.40. These figures must be increased about 30 per cent, however, for reserve capacity.

The cupola bottom absorption is relatively negligible. This is due to the fact that it is occupied on but a day's treatment of only a circulating by-product.

On the other hand, the doré-furnace bottom constitutes a very large item, due to the facts that it is a small furnace which means disproportionate brickwork, and that it treats something more than the entire silver and gold output in six day charges. The net result is that this accounts for about 12 days silver and 10 days gold.

The small absorption in the crucibles is neglected.

CONDUCTORS

We next have the copper tied up in conductors, etc., in the tank house and the silver in contact pieces leading the current in and out of the cells in the parting plant.

These copper parts in the tank house consist of bus-bars, cross rods (upon which the cathodes are hung) and starting blanks (the plates upon which the starting sheets are deposited).

It is customary to buy the main bus-bars outright as a charge against capital expense, so these do not enter into this discussion.

The other small parts are borrowed from the copper passing through the plant as they are made of refined copper and can be melted up at any time at a day's notice, were some extraordinary market condition to call for a final accounting in refined copper. Of course this loan has to be paid for in "metal interest" as it correspondingly lengthens the time required for refining. This method is really no different from that pursued in casting lugs upon the anodes in order to conveniently suspend them in the tanks.

The items in question amount to about 1.5 days production of copper.

The silver contact pieces in the parting plant are a small item, tying up about 0.1 of a day's production.

Finally we have the copper molds used for casting the wire bars, ingots, etc., and these tie up about 2.5 days production.

The total days lost from "metal withdrawn" is shown in Table IX.

TABLE IX			
Metals Withdrawn			
	Copper	Silver	Gold
Tank house electrolyte.....	0.60	0.40	....
Parting plant electrolyte.....	....	0.40	....
Anode furnace bottom.....	0.61	0.33	0.52
Refining furnace bottoms.....	0.52	....	....
Doré furnace bottoms.....	....	12.00	10.00
Conductors, etc.....	1.50	0.10	....
Moulds.....	2.50	....	....
Total days.....	5.73	12.83	10.52

We can now summarize the results of this review and Table X shows a total time required of 44 days for the copper, 69 days for the silver and 68 days for the gold.

TABLE X			
Summary of Metals Tied Up			
	Copper	Silver	Gold
Commercial.....	5.00	4.00	3.00
Technical—Direct process.....	24.00	34.00	37.00
Circulating.....	4.29	5.65	4.93
Withdrawn.....	5.73	12.83	10.52
Lost.....	....	....	....
Balancing.....	5.31	12.57	12.28
Total days.....	44.33	69.05	67.73

To these figures must be added any delays due to fires, strikes and other "unforeseen" causes, and it must further be remembered that running a plant at part capacity runs up the "metals withdrawn" and some other items.

Board of British Scientific Societies

On the initiative of the Royal Society (London) a Board of Scientific Societies has now been established for promoting the co-operation of those interested in pure or applied science, according to the *Iron and Coal Trades Review*. This supplies a means by which the scientific opinion of Great Britain may, on matters relating to science, industry and education, find effective expression; taking such action as may be necessary to promote the application of science to industries and to the service of the nation; and discussing scientific questions in which international co-operation seems advisable. The Board at present consists of representatives of twenty-seven scientific, including technical societies. The regulations give power to add to this number and to appoint as members of sub-committees individuals who are not necessarily connected with any of the constituent societies. An executive committee has been appointed consisting of the following members: Sir Joseph Thomson, O.M., P.R.S. (chairman), Dr. Dugald Clerk, Sir Robert Hadfield, Mr. A. D. Hall, Prof. Herbert Jackson (honorable secretary), Sir Alfred Keogh, Sir Ray Lankester, Prof. A. Schuster, Sir John Snell, Prof. E. H. Starling, Lord Sydenham, Mr. R. Threlfall.

New Sulphuric Acid Plant

The Construction of the Sulphuric Acid Plant and the Commercial Process of Manufacture of the Acid as Used by the United States Steel Corporation at Donora, Pa.

By T. N. HARRIS

Sacrificing everything for time, work was begun on this plant in June of 1915, and the first acid ran over the towers during the night of Dec. 22, 1915. This record-breaking time for construction operations should go down in engineering history as a marked example of results obtained from co-operation and organization among engineers and superintendents in charge of construction work.

In the following paragraphs the writer will endeavor



TOWER BUILDING AND ROASTING FURNACE

to describe briefly the construction of the equipment used for the manufacture of sulphuric acid (H_2SO_4), at the same time tracing the ore from the time it is unloaded at the ore bins until it is placed in the roasting furnaces where the sulphur is liberated and combined with oxygen from the air. Attention then will be given to the sulphur dioxide (SO_2) gas, thus formed as it passes over the nitre furnace, thence through the towers and chambers until it is concentrated to 60 deg. Baumé and then pumped into the storage tanks ready for drawing off into tank cars to be shipped.

ORE-HANDLING PLANT

This plant consists of the ore bins, sampling and crusher buildings. Australian ore is used chiefly in this process owing to the fact that the percentages of zinc and sulphur run much higher than in our own native ores. Zinc runs about 50 per cent, sulphur 25 to 30 per cent, about 6 ounces of silver, small quantities of lead and iron and a slight trace of gold.

This ore is jet black, weighs 150 lb. to the cubic foot, and some of it is as fine as flour. Approximately one ton of acid is made from the sulphur gases driven off from one ton of ore.

SAMPLING

Before the ore is placed in the bins, or while it is being unloaded, a representative sample is taken for assaying purposes. This process is carried on in the sampling building, directly adjacent to the ore bins and which forms a part of the ore-handling plant.

This ore is received at the plant in box cars; thus it is unloaded by the shovel and wheelbarrow method. As the unloading takes place a certain quantity is set aside, the quantity being arrived at by the simple expedient of setting aside every tenth shovel or every tenth wheelbarrow.

This sample is then thoroughly mixed; about 5 lb. of

it is placed in dryers to drive off the moisture. After a sufficient time has elapsed this moisture sample is weighed to obtain the percentage of moisture.

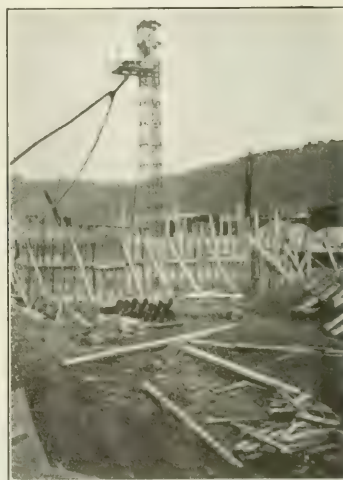
The remaining portion of the original sample is placed in a large dryer to drive off the moisture content, and is then run through a crusher which breaks up the lumps sufficiently to allow the ore to be more finely divided by a machine known as the rolls. The name of this machine tells the story of its duty. It consists essentially of two rolls or cylinders placed with their axes horizontal and their surfaces directly adjacent. The rolls revolve in opposite directions, and the ore on passing through is ground finer.

From the rolls the ore goes to the dividers, an arrangement for obtaining a mathematical division of the ore. This machine is a simple hopper arrangement with a slotted bottom, the alternate slots diverting the ore into two separate pans. The process may be repeated any number of times and thus as small a sample as wished may be obtained.

For assaying purposes the entire sample must pass through a hundred-mesh screen. In order that this condition may be fulfilled, the ore taken from the dividers is run through a pulverizer, which consists of two disks revolving in opposite directions and with arrangements for adjusting their proximity, thus assuring the passage of the final sample through a hundred-mesh screen.

ORE BINS

The bins are interesting from an engineering point of view, as they are wholly constructed of heavily reinforced concrete. They are ten in number, each bin being 70 ft. long, 20 ft. wide and averaging 18 ft. high, being 20 ft. high at one end and 16 ft. at the other. These are inside dimensions, so the total capacity of



90-FT. CONCRETE TOWER AT THE ORE BINS

the ten bins is 224,000 cu. ft., or approximately 15,000 tons of ore.

The walls separating the bins are 18 in. on top and average 32 in. at the bottom, being 3 ft. at the high end and 28 in. at the low end. They are reinforced longitudinally and vertically; longitudinally by $\frac{3}{4}$ in. square plain bars spaced 30 in. on centers, and vertically by 1 in. square plain bars placed 2 in. from each face spaced 6 in. on centers. Every third bar extends to within



DUST COLLECTOR FOUNDATIONS



ROASTING FURNACE TUNNEL

2 in. of the top of the wall while the two intervening bars extend only to the top of the middle third section of the wall. The end and side walls have the same reinforcement as the intermediate walls.

The bottom of the bins is a 2-ft. slab, reinforced longitudinally and transversely by $\frac{3}{4}$ -in. square bars 12 in. on centers, excepting under the walls, where the reinforcement is 1 in. square bars running longitudinally and transversely along the top and bottom of the slab on 18-in. centers.

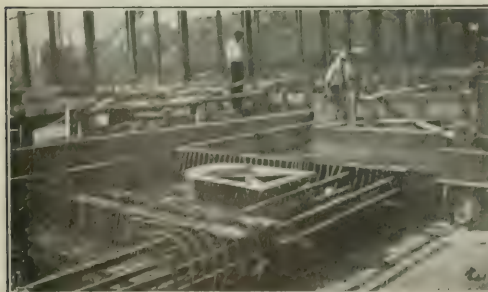
There was 3500 cu. yd. of concrete and 185 tons of reinforcing steel required for this work. The concrete in the bottom slab was a 1-2 $\frac{1}{2}$ -5 mix, while the walls were a 1-2-4 mix. Universal Portland cement was used exclusively in all the foundation work. The concrete for the ore bins was poured from two 90-ft. distributing towers rigged with a system of line gate chutes and completed in less than thirty days.

CRUSHER BUILDING

This building is enclosed by the same roof as the ore bins, the total length of the structure being 340 ft. and the width 75 ft. The equipment installed includes hoppers, screens, crushers, driers, dust collectors, skip hoists, storage bins, ore chutes, trestle for ore car and numerous electric motors.

The ore is taken from the bins by a 15-ton overhead electric traveling crane with a grab bucket and deposited in a large conical-shaped hopper, about 20 ft. in diameter. From the hopper it enters a revolving screen (42 in. diameter, 12 ft. long, $\frac{3}{4}$ in. perforations, 18 r.p.m.) where the fines are separated and passed on into the revolving driers (Ruggles Coles Class A-14, 60 ft. long, 7 ft diameter, weight 42 tons) and the coarse shunted off into a No. 6 Kenedy gyratory crusher.

Upon leaving the driers the ore is caught in a bucket which is elevated by a skip hoist and deposited in the storage bins from whence it is taken by the ore car to the roasting furnaces.



ROASTING FURNACE TUNNEL ROOF SLAB



SITE OF ROASTING FURNACES TAKEN FROM TOP OF 135-FT. CONCRETE STACK OF ROASTING FURNACE TUNNEL

The storage bins are accommodated on the 75-ft. level of the 130-ft. tower, which occupies the southern extremity of the building. This tower is 30 ft. wide and extends 75 ft. across from one side wall to the other. Besides the storage bins this tower accommodates a Newage separator (style No. 3) trestle for the ore car and six carbonate crushers of the roller type.

This plant is made up of two units whose operation calls for the use of twelve Westinghouse motors. Two 200-hp. motors drive the carbonate crushers, two 25-hp. motors operate the skips, two 65-hp. motors the driers, two 10-hp. for the screens, two 40-hp. the gyratory crushers and two 7 $\frac{1}{2}$ -hp. motors operate the fans to the dust collectors.

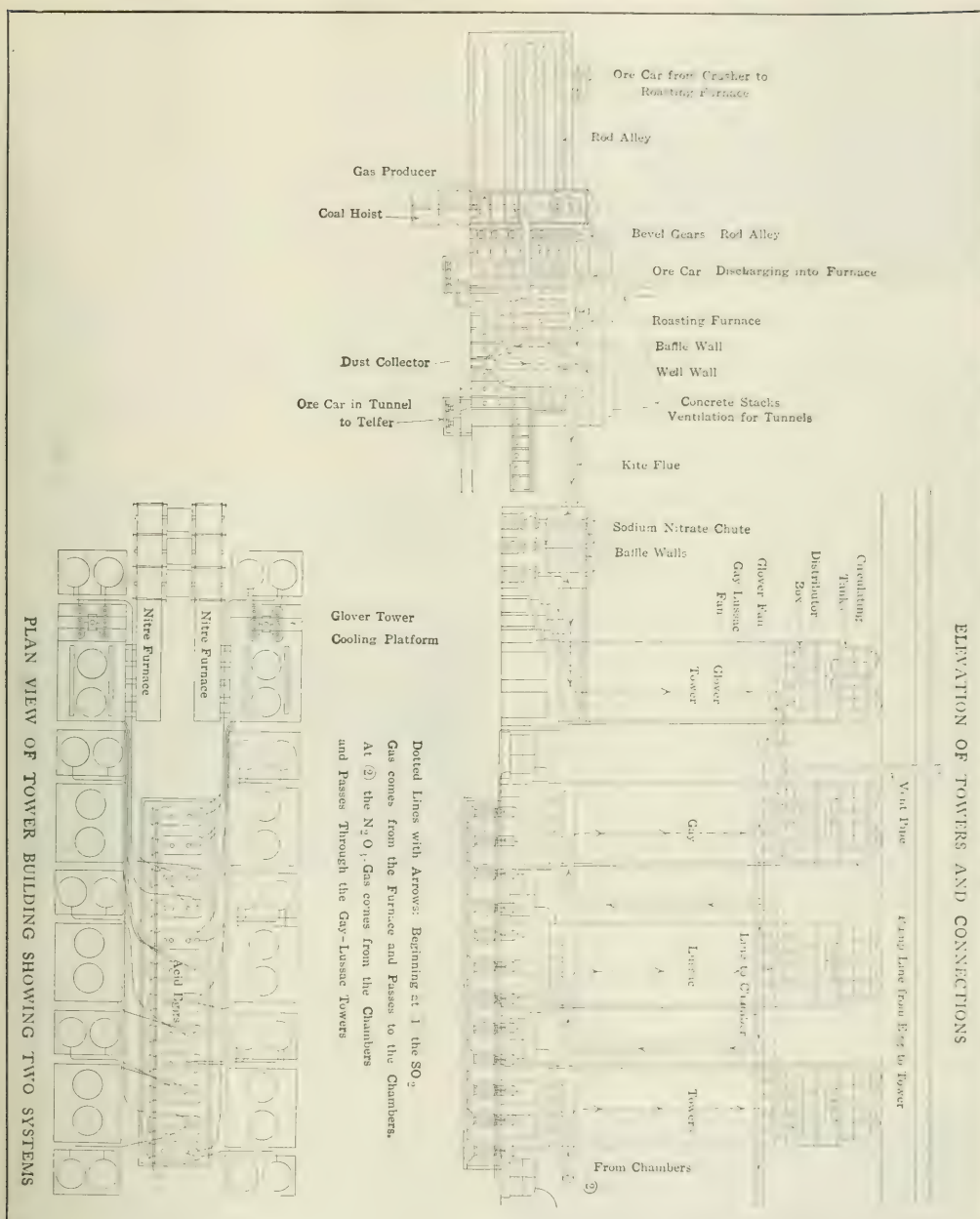
A 75-ft. reinforced concrete stack is used in connection with the driers. The structural steel used in the framing for the tower of this building is the heaviest type used on the entire work.

ROASTING FURNACES

The equipment necessary for roasting the ore and conveying the sulphurous gases to the nitre furnace includes the following: a large roast kiln, gas producer with large steel circular flues leading to the combustion chamber of the kiln, an air heater, rod alley, dust collector and kite-shaped flues leading from the roast kiln to the dust collector, thence to the nitre furnace.

The ore is received from the crusher by an ore car operated on a trestle which dumps into a hopper at the top of the furnace. It is now raked back and forth through the different hearths as it is being roasted by heat furnished by the producer gas method.

Chambers are provided for the admittance of air to the ore as it is being thus roasted which forms SO₂ gas as the sulphur is being liberated in gaseous form in the process. When the ore has been raked on down through



the furnace and reaches the bottom hearth it falls down through a chute into tunnels, one being constructed at each end of the furnace.

In the tunnels ore cars are operated from the chute, which takes the ore out of the furnace to the other end of the tunnel, where it can be loaded to the telfer car and is now ready for the distillation furnaces for the refining of the zinc.

Beginning with the roasting process the plant is divided into three units, each unit requiring four separate

buildings, two for the roasters, one for the towers and one for the chambers. Each unit is made up of two systems which is constituted by the following: The roasting furnace equipment as previously described, and one nitre furnace, one Glover tower, Gay-Lussac towers, ten chambers and one storage tank.

ROAST KILNS

These kilns are constructed on a husky concrete foundation, are 80 ft. long, 22 ft. high and 18 ft. wide and



COLUMN REINFORCEMENT ACID TOWER FOUNDATION

built up of red and fire brick, approximately one million 9-in. equivalent brick in each kiln.

The kilns are divided in half by a partition wall, each side having seven arched hearths, three gas chambers and a fire flue.

The buck-staves are thirty-six in number, eighteen on each side of the kiln and connected at top and bottom crosswise of the kiln by two $2\frac{1}{2}$ -in. tie rods.

On each buck-staves at the end of the kiln a spring is placed both at the top and bottom so that a long tie rod extending the entire length of the kiln may connect the two springs at the top and the two at the bottom.

All of the buck-staves are firmly grouted in the concrete foundation of the kiln.

The arches for the different hearths and gas chambers are built of tongue and grooved brick block 9 in. x 9 in. x 4 in. and keyed at the sides of the arches with cast iron wedges.

There are gas openings in all of the arches, and the ore slots are placed toward each end of the kiln but on alternate hearths so that the ore being dropped from one hearth is raked clear across the hearth before it will drop to the hearth below.

There are two rod alleys and two sets of rods for each side of the kiln, one being placed at each end.

One rake is required for each hearth. After being drawn through on one hearth it is pulled out on a turntable and brought around to the end of the hearth on the same level on the other side of the kiln.

ROD ALLEYS

The rod alley and raking system consists of a large head frame supporting a system of bevel gears which operate an endless chain. These chains are placed level with the bottom of each ore hearth so that the long rods may be operated back and forth by means of a hook on the rod clinging to a large link in the endless chain.

By reversing the gears the rod is pushed through the

hearth and coupled to the rake, and by setting the gears in forward motion the rake is drawn through the hearth and when it comes nearly to the end of the hearth the ore drops through the slot in the arch and charges the rake waiting in the hearth below ready to be drawn in the opposite direction from which it was drawn in the hearth above.

Thus two rakes are operated at the same time in opposite directions in the same side of the kiln. This roasting kiln and raking system is of the old Hegeler principle with a few modifications.

DUST COLLECTOR

As the SO_2 gas is given off during the process of roasting, it comes out at the top of the kiln and is drawn over to the dust collector through a kite-shaped flue due to a suction created by a large lead fan to be described in connection with the towers.

In this dust chamber is a 3-ft. diameter well wall and eight baffle walls on the sides.

The chamber is of steel plate construction, 20 ft. in diameter, 30 ft. in height, conical in shape at top and bottom, and is lined with 2 in. of asbestos and 9 in. of fire brick.

The purpose of this chamber is to collect the dust from the gas as it falls down during the circulation around the baffle walls.

A drop door is placed at the bottom of the lower cone through which the dust is taken out.



FOUNDATION FOR ROD ALLEYS

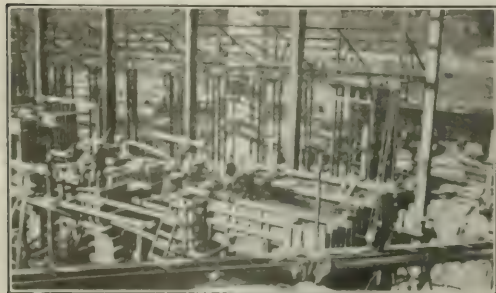
The SO_2 gas is admitted to the chamber at a point about two-thirds of its height, is drawn down around the baffle walls, enters the well wall through openings at the bottom, passing up through and out at the top of the well into another kite-shaped flue which leads over the top of the nitre furnace. These kite flues are of steel plate construction and lined with asbestos and fire brick.

NITRE FURNACE

The nitre furnace is built up of red and fire brick and constructed in three parts for the use of three pots and three grates.

There is an opening in the top arch of the furnace directly over each pot for the round chute through which sodium nitrate is poured down into the pot.

A lead pipe connection to each pot from the Glover tower conveys sulphuric acid into the pot. A coke fire underneath the pot heats this mixture forming sodium sulphate and frees nitrous fumes which are taken up by the SO_2 gas as it is drawn over the pots through the flue from the dust collector. This newly formed gas next passes through a brick flue into a four sectional throat flue at the side and bottom of the Glover tower. The nitre furnaces are located in the tower building in the



ACID TOWER FOUNDATIONS

center at the end between the Glover towers. (See plan of arrangement, page 315.)

ACID TOWERS

The foundations for each acid tower had to sustain a dead and live loading totaling 700 tons; thus they were constructed of reinforced concrete.

A slab, 20 ft. square, 12 in. thick, was built and carried on six 16-in. reinforced beams. This structure was supported by nine columns 36 in. square, the lower 10 ft. of the column was battered $1\frac{1}{2}$ in. per foot, and a footer pad 24 ft. square 24 in. thick formed the base of the whole mass. This reinforcement is shown in the accompanying cut.

Three-quarter-inch and 1-in. square plain bars were used throughout the work.

The floor slab of the tower was reinforced both ways in top and bottom. No. 1 plain wire was used for stirrups and lacing of the columns.

The towers are entirely lead-lined. In the bottom of the Glover tower the lining was 1 in. thick, weighing 60 lbs. per square foot. The sides of the tower were lined with 30 lb. lead.

Twenty and 30 lb. lead was used for the linings of the Gay-Lussac towers.

The lining of the Glover tower being heavier than the other towers is due to the fact that the temperature is much higher; at times it registers about 150 deg. Centigrade.



FOUNDATION AND FRAMING FOR SUPERSTRUCTURE FOR CHAMBER BUILDING

head at one end and oval shaped at the other. They are placed on their side and supported on brick piers.

Six eggs are required for each system, and are located in a pit immediately between the two systems of Gay-Lussac towers.

The eggs are connected separately to an air line, and each egg has a separate lead pipe connection with two towers. These pipe lines are fitted with valves so that as the acid drains from one tower into the egg it can be pumped up over another tower.

At the top of the towers are large circular tanks which receive the acid as it is pumped from the eggs. These tanks drain into distributor boxes which in turn outlet into 156 lead pipes which equalize the flow of acid over the square area of the tower.

LEAD FANS

There are two large lead fans, that are electrically driven, to each system.

One fan is located in the line of 36 in. diameter lead pipe connecting the Glover tower with the chambers.

The other fan is in a line of same diameter lead pipe connecting the chambers with the three Gay-Lussac towers. This line leads from the top of the chambers to the bottom of the first Gay-Lussac tower. This tower outlets at the top and another 36-in. pipe connects with the bottom of the next Gay-Lussac tower.

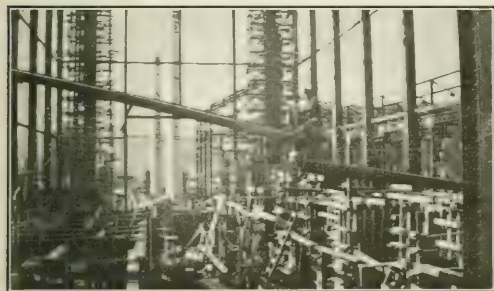
These three towers are connected with each other but not with the Glover tower.

CHAMBERS

The chambers are rectangular in shape, 18 ft. wide, 20 ft. high, and vary from 40 to 60 ft. in length.

The bottoms, tops and sides are made up of 6, 8 and 10 lb. lead.

The chambers are connected with each other and with the towers, one line leading from the Glover tower to



ACID TOWER FOUNDATION

The Glover tower which receives the gas from the nitre furnace is called the cooling and concentrating tower, one of which is required to a system.

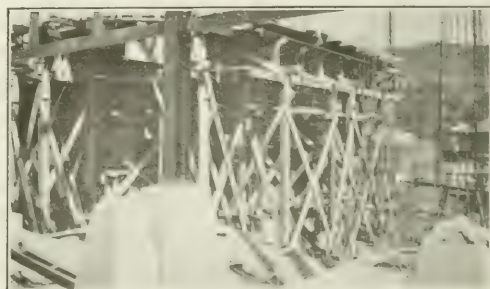
Three Gay-Lussac towers are required to a system, and they receive the gas after it has made the circuit through the chambers. The towers take the nitre out of the chamber acid as it is pumped up over them after it has made a passage from the Glover tower.

All of the towers are 30 ft. in height above the foundations and 14 ft. square. They are packed with hard-burned chemical brick; about 63,000 used in the Glover tower and throat flue leading to the tower. About 59,000 in each of the two Gay-Lussac towers and 53,000 in the Gay-Lussac tower nearest the chambers. The last 10 ft. in the top of this Gay-Lussac tower is packed with large pieces of 72-hour coke.

The brick used for packing the towers is the size of paving brick weighing about 10 lbs. each, and are laid up in checker formation. The checker openings in the bottom 10 ft. section of the tower were 4 in., the middle section openings were 3 in. and the top section 2 in.

ACID EGGS

The acid eggs are iron castings 2 in. thick, of cylindrical shape, 3 ft. in diameter, 12 ft. long with a flanged



FORM WORK STORAGE TANK FOUNDATIONS



STORAGE TANKS

the chambers and the other line leading from the chambers to the Gay-Lussac towers.

CIRCUIT THROUGH THE TOWERS AND CHAMBERS

Going back to the gas formed in the nitre furnace, the SO_2 gas combined with the nitrous fumes. By the suction of the Glover tower fan this gas is drawn up through the Glover tower and pushed to the chambers. Here steam is admitted to the chambers, and by breaking up with the nitrous gas and the SO_2 , a weak solution of sulphuric acid is formed, also a brown gas called nitrous trioxid.

This weak acid is now known as chamber acid which formed in a vapor condensed on the sides of the chambers and dripped to the bottom flowing to an outlet into a line that drains into the egg known as the chamber acid egg.

The nitrous trioxid gas rises to the top of the chambers and the fan on the line with the Gay-Lussac towers pulls this gas into the bottom of the first Gay-Lussac tower up through this tower and on through the other two Gay-Lussac towers.

The weak solution of sulphuric acid is now pumped over the Glover tower, trickling down through the tower washing the SO_2 gas and nitrous fumes which are continually being drawn through by the Glover tower fan from the furnaces.

This chamber acid continues to take up more SO_2 from the Glover tower and drains into tanks on the cooling platform, where the acid is tested for 60 deg. Baumé.

These test tanks are constructed of lead, and contain a coil of lead pipe through which cold water runs continuously.

Until the acid reaches the desired strength it drains from the cooling platform of the Glover tower to the acid eggs, and is pumped up over the Gay-Lussac towers for the nitre to be taken out.

After circulating through these three towers it is

again pumped over the Glover tower to receive more SO_2 . When the hydrometer registers 60 deg. on the cooling platform the acid is drained into the storage egg, from which it is pumped into large steel storage tanks located at the railroad siding where the tank cars are loaded.

STORAGE TANKS

The storage tanks, six in number, were constructed of $\frac{7}{8}$ -in., $\frac{3}{4}$ -in., $\frac{5}{8}$ -in. and $\frac{1}{2}$ -in. steel plate with no lining of any kind whatsoever.

The structure was carefully calked as proof against leakage, and was absolutely air-tight. Acid does not attack the steel of the tank without the presence of air.

The tanks are 40 ft. in diameter and 20 ft. in height. Each tank required a foundation good for a loading of 1700 tons. These foundations were of reinforced concrete, the structure consisting of a 20-in. slab 48 ft. in diameter carried on four beams 30 in. wide and 36 in. deep, supported by twelve columns 30 in. square.

The lower 10 ft. at the base of the columns was battered 3 in. per foot. Each column had a footer pad 24 in. thick and 9 ft. square. One-inch-square plain bars were used in the columns, beams and slab. Three-eighth-inch plain rod was used for temperature stress bars and No. 1 plain wire used for lacing the columns.

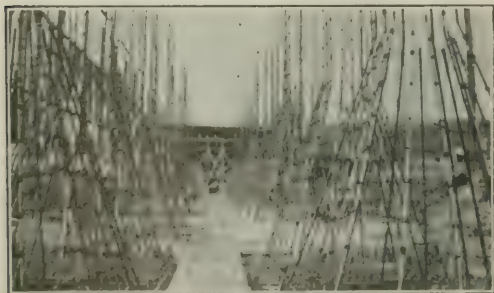
The buildings of the entire plant are of the latest type of mill structures. They are fireproof in every case; the side walls are built of hollow tile, the framing is all of structural steel and the roofs are of tar paper and corrugated tar felt construction.

The machinery throughout the plant is electrically driven, the power being furnished by a specially designed equipment of the company.

Synthesis of Ammonia

Some interesting experiments on the synthesis of ammonia from nitrogen and hydrogen in their atomic, nascent state, are described in the *Chemical Trade Journal and Chemical Engineering*, Aug. 5, 1916, the data being taken from a communication of Dr. Zenghelis to the Paris Académie des Sciences:

Zenghelis passed, in his first experiments, a mixture of the gases—three parts by volume of hydrogen and one part of nitrogen—through water (acidified with sulphur dioxide in some experiments) in which the catalyst was suspended; the water was heated, but only up to 90° C. Some ammonia was obtained, especially with colloidal palladium or silver as catalysts; but the yields were very poor, and electrolytic and chemically-evolved hydrogen did not give better results. In the second series of experiments the nitrogen was atomic; the hydrogen not. The nitrogen was generated from sodium nitrite and ammonium chloride; this reaction gives free nitrogen and also some nitric oxide and ammonia, which had to be allowed for in the estimates of the ammonia produced. The yields were again very low, although the experiments were continued for more than four hours. In the third series both the elements were in the nascent state, the nitrogen was generated, as in the second series and the hydrogen as in the first, and then decidedly promising results were realized. The temperature ranged from 70° to 99° C.—that is to say, the water was not quite boiling. If all the nitrogen had been converted into ammonia, 5000 cu. cm. of ammonia solution should have been obtained; with spongy palladium 321 cu. cm. were actually found, with colloidal platinum 1755 cu. cm., and with colloidal palladium 1025 and even 2060 cu. cm.; in the last-mentioned case there was more of the catalyst. Thus the yield came up to 40 per cent. The trouble is that the nitrogen was generated from materials as valuable as the ammonia produced.



COLUMN REINFORCEMENT STORAGE TANK FOUNDATION

Recent Developments in Zinc Concentration Practice in the Joplin District, Missouri

BY H. C. PARMELEE

Joplin milling practice has always been unique; not only for its remarkable accomplishments, but also for its deficiencies; as well for the development of interesting local methods as for an apparent disregard of foreign ideas; as much for its independence as for a failure to adopt refinements considered indispensable in other districts. Financially, Joplin milling has been a success; metallurgically it has been at once the admiration and despair of outside engineers—admiration for the success of special methods developed to meet peculiar local needs, and despair at the evident lack of appreciation of some of the finer points in ore-dressing.

But in spite of admitted deficiencies in the past, Joplin mill practice is improving and there are evidences that it is getting on a sounder engineering basis. The newer mills show more attention to the details of classification, regrinding, and the concentration of sand and slime. Efficiency is improved and losses have been recognized and reduced.

One reason assigned for the slowness with which milling has advanced is that mining has been considered more important and has offered the opportunity for quick money-making, even with crude milling methods. Under the leasing system which generally prevails, mining and milling have been done cheaply, but milling has generally been a secondary matter both as to equipment and efficiency, because the time and extent of the leases were limited and soon exhausted. There is no doubt, however, that the time is at hand when more attention is being paid to ore-dressing in the Joplin district in order to prevent waste and increase profit.

Hitherto mills have not been designed on the basis of preliminary tests, such as are made in other places, but they have been erected by contractors who turn over a typical Joplin mill at a fixed price. Operators have followed local custom closely and have been slow to depart therefrom. Perhaps this is because past efforts to improve conditions have been too radical, proposing to revolutionize the whole practice without recognizing the things that Joplin already does well. Those most familiar with local conditions realize that this is not what is needed, but that improvements undoubtedly can be made in important details throughout, and particularly with regard to the recovery of finely ground mineral. Past losses in this respect are indicated by numerous projects for reclaiming fine mineral from old tailing piles and ponds.

Bureau of Mines Studies

An important factor in arousing an interest in better ore-dressing has been the study of local methods conducted by the U. S. Bureau of Mines under the direction of Clarence A. Wright. The reports¹ thus far issued are preliminary to a final document covering the mining and treatment of lead and zinc ores in the Joplin district, based on co-operative work between the Missouri Geological Survey and the U. S. Bureau of Mines. The general result of this work has been to prove definitely the losses sustained in milling and to indicate where and how they may be prevented. Thus it was shown that the average recovery of zinc from the ore, taking the district as a whole, was about 65 per

cent, and the deficiencies of jig and table practice were pointed out. The following general outline of the jigging system is given by Mr. Wright.

Outline of Jigging System

"The most common type of jig used in this district is known as the Cooley, similar in principle to the Harz jig. It is of the fixed-sieve type, the water being forced up and down through the screen or grate by the action of a plunger placed in an adjacent compartment. The number and the size of the compartments for each jig depend on the size and character of the ore treated.

"In general, a system of 'roughing' and 'cleaning' is followed in which the feed is given a preliminary cleaning that eliminates the greater proportion of waste material on one or two 'rougher' jigs. The enriched product, which will assay about 14 to 18 per cent zinc, is cleaned on a 'cleaner' jig for the final treatment, bringing the zinc tenor up to 55 to 60 per cent. The 'chats' or included-mineral particles from both the rougher and the cleaner jigs, which together will assay 4 to 8 per cent zinc, are recrushed and either returned to the rougher-jig feed or treated separately over a 'chat' jig. The tailing from the rougher jig is dewatered by means of a dewatering trommel with 1½- mm. to 2-mm. openings, over the outside of which the tailing passes as the trommel slowly revolves. The undersize from this dewatering screen flows to the settling tanks and the oversize to the tailing elevator as waste. The overflow from the tailing end of the cleaner jig, and other jigs if used, also passes to the settling tanks for subsequent treatment.

"The rougher jigs usually consist of five or six cells with a screen or grate area in each cell of 30 by 42 in. to 36 by 48 in. The speed of the shaft connecting the plungers and eccentrics varies from 90 to 120 r.p.m., with the length of stroke of the plungers ranging from ¾ in. to 1¼ in. The cleaner jigs have six to seven cells with a grate area somewhat smaller than that of the rougher jig. The speed of the shaft connecting the eccentrics and plungers is from 160 to 200 strokes per minute, with lengths of stroke ranging from ¾ to ¾ in. The chat jigs, which are not commonly used, are smaller and usually consist of four to five cells, and are operated at a higher speed and shorter stroke.

"The material fed to the first cell of the jig is, as a rule, not graded or classified. A bed 5 to 6 in. deep is formed and as a result of the pulsating action of the water the lighter gangue material, such as flint, comes to the surface, the heavier free grains of lead and zinc working to the bottom. The downward suction stroke causes the finer grains of mineral to continue through the screen or grate openings into the hutch of each compartment. The strength of the suction stroke is increased by leaving the gates of the hutch partly open. The accumulation in the hutch is known as 'smitten' and is further treated on the cleaner jig. The bed products of the first two or three cells are also drawn off and pass together with the hutch product to the cleaner jig. The chats or included mineral particles, usually from the last hutch and the last two or three beds, are drawn off and reground before further treatment."

Loss of Fine Mineral in Jigging

A feature of Joplin jigging which always impresses the visitor is the unusual practice of treating an ungraded or mixed feed, ranging in size from ½ in. to dust. Another point is the large amount of water used in transporting the material through the jig. Both of these features undoubtedly contribute to the loss of

¹Four papers have been written by Clarence A. Wright: *Technical Paper 41*, Mining and Treatment of Lead and Zinc Ores in the Joplin District, Mo.; and separate preliminary papers on Jig Concentration, Table Concentration, and the Possibilities of Flotation.

fine and slime mineral in the jig tailing and have an unfavorable effect on the efficiency of the jig.

Through its investigations on jigging ungraded feed, the Bureau of Mines has shown very definitely by screen analyses and assays that the fine grades are the richest in zinc and cause the greatest losses. Thus in a jig feed of free sheet-ground ore averaging 1.13 per cent zinc, the portion minus 200-mesh amounted to only 3.28 per cent of the whole, but it had an assay value of 5.77 per cent zinc and represented 16.81 per cent of all zinc in the feed. Quite naturally, under the prevailing operating conditions, this fine material largely remained in the tailing, a screen analysis of which showed 3.62 per cent minus 200-mesh material, assaying 4.5 per cent zinc and representing 32.26 per cent of the zinc in the tailing. Even in the dewatered tailing, from which the fine mineral is supposed to have been removed by screening before the oversize goes to the dump, there was 1.09 per cent of material finer than 200-mesh, assaying 4.20 per cent zinc and representing 12.12 per cent of the total zinc going to the dump.

This condition of slimy feed is emphasized even more strongly in the case of a "chatty" ore, where the mineral is not so free as in the preceding case. Where the average jig feed of such an ore assayed 1.99 per cent zinc, there was 12.43 per cent of material finer than 200-mesh assaying 2.25 per cent zinc and representing 14.13 per cent of the total zinc in the feed. The jig tailing before dewatering contained 10.03 per cent minus 200-mesh material assaying 1.45 per cent zinc and representing 16.7 per cent of the total zinc in the tailing. The dewatered tailing contained 3.79 per cent of material finer than 200-mesh, assaying 1.4 per cent zinc and representing 6.5 per cent of the total zinc lost.

These examples are typical of general conditions and point clearly to one source of preventable loss. An obvious remedy is to deslime the jig feed, thereby immediately removing part of the pulp suitable for table concentration and leaving a clean coarse feed for the jig. Another reason for desliming before jigging is that the screening of jig tailing for recovery of fine mineral is quite inefficient.

Inefficiency of Screening

A typical example will be taken from the Bureau of Mines report, with reference to a 1.5-mm. screen.

$$\text{Efficiency} = \frac{\text{Weight of undersize passing through screen}}{\text{Total weight of undersize in feed to screen}}$$

Screen Product, Size Opening	Screen Feed, per Cent	Screen Oversize, per Cent
Over 1.5 mm.	80.1	17.5
Thru 1.5 mm.	19.9	12.5
	100.0	100.0

$$\text{Weight of undersize in the oversize} = \frac{80.1 \times 12.5}{100} = 10.01$$

$$\text{Screening efficiency} = \frac{19.9 - 10.01}{19.9} = 49.7\%$$

The method of handling chats or middlings, material requiring regrinding in order to free the included mineral, is not as logical or satisfactory as could be desired. Local custom dictates regrinding with rolls and generally a return of the product to the jig of origin. In some cases the more logical step is followed of re-treating the reground product over a separate jig. The latter plan offers a number of advantages, for the chats are an enriched product which will yield a higher recovery if treated separately than when mixed with

original feed of lower grade. Further, separate treatment avoids the addition of more fine material to the rougher jig which, in the absence of desliming, is already overburdened with fine and slime material.

Table Concentration More Widely Practised

The concentration of sand and slime pulps by reciprocating tables has shown a marked improvement in the Joplin district in the last few years. The number of tables in use in a mill has increased, so that table capacity is more nearly proportionate to the tonnage to be treated. In accounting for the deficiencies of table concentration in Joplin it must be recalled that the operator has bent his efforts toward coarse concentration on jigs and has done as little fine grinding as possible. In times past it has been even a matter of pride with some operators to have as few tables in the mill as possible, in some cases none at all. In contrast to this condition is the present tendency toward better

TABLE I.—RESULTS OF TESTS OF TABLE SECTIONS IN VARIOUS MILLS.

Test No.	Number of Tables in Operation	Zinc Content of Feed to Tables, per Cent	Zinc Content of Concentrates Produced From Tables, per Cent	Zinc Content of Tailings From Tables, per Cent	Percentage of Zinc Recovered	Character of Ore Treated
1	1	6.35	58.0	3.75	43.8	Chatty
2	1	4.90	59.2	1.50	71.2	Free
3	2	2.95	55.6	1.35	55.5	Chatty
4	2	4.85	57.4	1.70	67.0	Chatty
5	2	4.70	57.0	1.55	69.0	Chatty
6	2	3.12	54.5	1.00	69.1	Chatty
7	2	4.30	56.2	1.35	70.2	Chatty
8	2	5.65	57.1	1.62	73.5	Free
9	2	7.75	57.2	2.25	73.9	Free
10	3	3.75	52.8	1.29	69.5	Chatty
11	3	6.75	54.6	1.55	79.4	Free
12	5	4.65	42.0	1.30	74.3	Chatty
13	6	3.95	59.3	1.19	71.3	Free
14	7	4.65	55.0	1.42	71.3	Chatty

classification, provision for uniform table feed, and more extensive and efficient tabling. As in the case of jigging, more attention is being paid to regrinding middlings, with treatment on separate tables instead of returning to the table of origin.

Table feed is made up mainly of the fine material separated from jig tailing as it passes over the dewatering screen at the end of the jig. This pulp flows to settling boxes from which it is later pumped to the classifiers and tables. In some cases a sand-slime separation is made mechanically, as with Dorr classifiers, after which the sand is hydraulically classified into several products and the slime thickened in Dorr thickeners prior to tabling. Flotation is being adopted in some instances for the treatment of slime tailing.

The efficiency of table concentration varies with the ore, i.e., whether "free" or "chatty," being higher for the first type and lower for the second. From the detailed study made by the Bureau of Mines, previously mentioned, we select Table I to illustrate this point.

Slime Losses in Table Concentration

Losses in table concentration as determined by screen analyses and assays of tailings show plainly the detrimental effect of slime; and this, in turn, suggests the need of better classification to relieve sandy pulps from minus 200-mesh material. In a study of six tables treating a classified pulp, two of them handling slime finer than 200-mesh, the percentage of that grade in the feed to each table ranged from 9.7 to 91.2, and the loss of zinc in the tailing was contained, for the most part, in that size. Owing to poor classification the pulp going to sand tables contained too much slime, while the slime tables were handicapped by receiving too thin a pulp. The average zinc content of feed to all tables

was 3.95 per cent; of concentrates from all tables 59.3 per cent; of tailings from all tables 1.19 per cent; average percentage recovery 71.3. A screen analysis of total tailings from the six tables showed that 15.5 per cent of the material was minus 200-mesh, assaying 5.07 per cent zinc and representing 65.78 per cent of the total loss in tailings. These results were obtained on a "free" ore; similar tests on a "chatty" ore showed the necessity of regrinding middlings.

From these tests it is apparent that still further improvement can be made in Joplin table practice by proper classification and sizing, suitable pulp density, re-treatment of middlings and mixed products, and attention to the details of table operation. The newer mills are embodying many of these improvements, as will be pointed out later in a descriptive article. Further improvement will come as technical knowledge is disseminated and its benefits appreciated.

Possibilities of Flotation

In view of the evident importance of the slime problem in Joplin, flotation is naturally considered as a solution. A number of mills are now using this process in an experimental way with considerable success. At least one flotation plant has been built to retreat an old dump and other similar plants are in prospect. The Bureau of Mines studied this phase of Joplin milling and made a number of practical tests.

The comparatively small capacity of Joplin mills and short life of the leases make it necessary to consider the quantity of material that might be available for flotation and the economy of installing a special plant for its treatment. Owing to the varying character of the ores, the amount of fine material produced in crushing is not a constant for all mills. Taking 65-mesh (0.208 mm.) as a dividing line, screen analyses of tailings from several mills showed that the percentage of material passing that mesh ranged from 3 to 16, according to the ore and fineness of original crushing. Soft-ground ore yielded more fine material than sheet-ground, but the finest sizes of the latter showed a higher zinc assay than the former. If the mineral in material passing 35-mesh (0.417 mm.) should prove fine enough for flotation, it would appear that a sheet-ground mill of 300 tons capacity would produce about 15 tons of flotation feed per day, and this is considered about the smallest tonnage that would warrant an installation. It might be found profitable to regrind part of the sand tailings in order to supply a suitable tonnage. The economy of the whole proposition would depend on the grade of the material, cost of operation and the market for concentrates.

Actual experiments by the Bureau of Mines on the flotation of Joplin zinc slime showed that "it is fairly easy to float the sphalerite from the gangue by using warm solutions and about 1 lb. per ton of any suitable oil, either from wood or coal distillation, and that acidity, although it does not seem to be necessary, allows the froth and tailings to separate more quickly. Cold solutions gave as high extractions as warm solutions, but the grade of the concentrates was not as high.

"A scheme making use of rougher and cleaner units of flotation cells seems essential in order to get a high extraction and concentrates of acceptable grade.

"In the experiments made in Joplin, the thickness (ratio of solids to water) of the pulp treated ranged from 1:3 to 1:7. In practice the most favorable ratios for different ores would, of course, have to be determined by experiment.

"In general, a mixture of sand and slime requires a denser pulp, whereas for a mixture consisting wholly of slime (finer than 200-mesh) a thinner pulp is desirable.

Thickening of the slimes from the Joplin district mills would be necessary, and could be accomplished by the use of Dorr thickeners or some other device that would give the flotation machines a uniform feed of constant thickness.

"The addition of acid may not be absolutely essential for all the ores of the Joplin District, although the local tests showed that a small quantity of acid was of great help, especially in cleaning the concentrates."

Flotation will undoubtedly prove a profitable accessory process in Joplin mills, and its introduction should be encouraged in an experimental way until its peculiarities are understood. If the possible improvements in jigging and tabling are carried out as indicated earlier in this article, there may not be the field for flotation at some mills which now are in need of a method of reducing slime losses. On the other hand the larger mills are likely to find a place for the process, while for retreating old dumps and slime ponds it is almost certain to be used to advantage. At the present time the Joplin district is regarded as offering opportunities to trained metallurgists who can see and improve the weak points in present practice; at the same time it is good advice to prospective reformers to study local conditions carefully, accept the successful features and make haste slowly in adopting radical changes.

The Effect of Corrosion on the Ductility and Strength of Brass*

BY PAUL D. MERICA.

Investigation¹ of the last few years has established the fact that brass will crack or fracture when exposed to the action of corroding agents, while at the same time under tensile stress, even when the value of this stress is much less than the ultimate strength or even the yield point of the material, as determined in the tensile test.

It is well known that surface corrosion plays an important part, even a necessary one, in the "season-cracking" of brass, and Jonson² has carried out a number of experiments, in which he has subjected brass test specimens to tensile stress in a testing machine, the specimens being at the same time immersed in a solution of concentrated ammonium hydroxide. He found that so long as the applied stress in these tests was not greater than the elastic limit of the material, the specimens did not fail, but when a stress was applied greater than this limit, *e.g.*, from 20,000 to 40,000 lb. per square inch, cracks would appear after a few days, the specimen would yield continually and finally break.

The effect of corrosion, at least of that caused by the action of ammonium hydroxide, on brass under stress, be it initial or due to external load, is to decrease the strength and also the ductility of the material, for it is a striking feature of such brass failures as occur, due to combined stress and corrosion, that they occur with little elongation; the brass does not display its usual ductility.

Parallel to his stress-corrosion tests, Jonson ran tensile tests on specimens of the same materials, subjecting them to the same loads, but not at the same time to the

*To be published also as a Technologic Paper of the Bureau of Standards.

¹E. Heyn, Internal Stresses in Cold-wrought Bars, and Some Troubles Caused Thereby, *Journ. Inst. Metals*, Vol. XII, 1914, p. 3.

²A. D. Flinn, Brass in Engineering Construction, *Engineering Record*, Vol. 68, 1913, p. 327.

³P. D. Merica and R. W. Woodward, The Failure of Structural Brass, *Trans. Amer. Inst. Metals*, 1915.

⁴E. Jonson, Failures of Forgive Brass Bars, *Trans. Amer. Inst. Metals*, Vol. VIII, 1914, p. 135.

⁵The Fatigue of Copper Alloys, *Proc. Amer. Soc. Test. Materials*, Vol. XL, 1915, p. 101.

action of the ammonium hydroxide; such specimens did not fail after months of test.

Furthermore, specimens were corroded with ammonium hydroxide and subsequently tested in tension, giving quite normal results, such that it must be considered that it is the simultaneous effect or action of tensile stress and corrosion (ammonium hydroxide), which produces failure in brass at stresses below its ultimate strength.

It may here be noted that Jonson used only ammonium hydroxide in his tests; he draws, however, the conclusion that any corroding agent, even water, will in time produce the same effect of cracking. The admissibility of this further conclusion seems probable, but is not to be regarded yet as proven.

The author wishes to advance an explanation for this rather striking phenomenon, of the combined action of tensile stress and corrosion on brass, indicating the actual manner or "mechanism" by which this effect is produced, in the hope that this explanation will contribute to progress in dealing with this important technologic problem.

The initial effect of corrosion on any metal, stressed or unstressed, is to roughen the surface, such that in section it appears with ridges or furrows. This non-uniform action of the corroding agent is due to slight variations of the electrolytic (solution) potential over the original (smooth) surface; in the case of a non-homogeneous alloy such as an alpha-beta brass—type, 60 per cent copper and 40 per cent zinc—a difference of potential would in general exist between the alpha and the beta constituents. If the corroded bar were under tensile stress, the value of the fiber stress at the surface would, theoretically at least for a long bar, be the same at all points; this can no longer be true, however, of the roughened surface.

Leon¹ has shown that the stress at the bottom of a semi-circular notch, in a tensionally stressed bar, is twice that of the average stress for the section, and that for sharper notches the stress might, at least for hard rubber, be as much as five times the average stress. The stress at the free edges of the notch is under such circumstances practically zero. The fiber stress along the roughened surface will, therefore, vary in value between zero, at the tops of the small ridges, and a value, at the bottom of the furrows, much larger than that of the average stress.

Now the electrolytic potential of a metal or alloy is increased, i.e., made more electropositive, by the application of a stress; the results of some measurements and further discussion of this effect of stress on the solution potential will be given later on.

It is therefore evident that after the formation of the furrowed or roughened surface on the brass specimen under tension, the e.m.f. will be greater at the bottom of the small nicks or notches than on the side of these notches immediately adjacent. Other things being equal, corrosion will therefore be more severe at the bottom of these notches than elsewhere, and the notches will grow inward, becoming sharper and sharper, quite in contrast to their behavior when uncorroded, since in a ductile material such notches tend to flatten or smooth out under tension, thus reducing the local fiber stresses at these points.

In fact, Heyn² finds that the behavior of a notch in a bar under tensional stress distinguishes brittle from ductile material. The notch in a ductile material tends

to smooth out, whereas in the brittle material it becomes sharper and narrower under tension, finally causing fracture. Thus the effect of corrosion under stress is to favor the growth and narrowing down of cracks and to cause an apparent brittleness of the brass.

MEASUREMENT OF THE ELECTROLYTIC POTENTIAL OF BRASS UNDER STRESS

The increase of electrolytic e.m.f. of a simple metal to a solution (containing ions of the same metal) due to the application of a stress may be calculated³ from the consideration that the increase of e.m.f. of a system is proportional to the increase of free energy, and that for isothermal, reversible processes the increase of free energy of a system is equal to the amount of work done on it.

The application of stress of values below the true elastic limit is a reversible process and can be carried out isothermally.

Considering, for the purpose of simple and approximate calculation, that brass is a simple metal of equivalent weight equal to

$$\frac{63 + 65}{2 \times 2} = 32$$

a stress of 25,000 lbs. sq. in., applied isothermally to a brass rod, having a modulus of elasticity of 15×10^6 lbs. per sq. in., and a density of 8, should produce an increase of e.m.f. equal to

$$\frac{\text{work (in ergs)}}{\text{density}} \times \frac{\text{equivalent weight} \times 10^{-7}}{96,500}$$

$$= \frac{25,000}{2} \times \frac{25,000}{15,000,000} \times \frac{1,000 \times 980}{14.2} \times 32 \times 10^{-7}$$

$$= \frac{96,500 \times 8}{96,500 \times 8}$$

= 0.000006 volts.

With greater stresses and after plastic yielding had commenced, an increase of 2 millivolts might be obtained, assuming that one-half of the energy of deformation is potentialized.

Some measurements have been made of these quantities, with, however, contradictory results.

Hambuechen (loc. cit.) finds for brass—composition of the brass and of the electrolyte not stated—an increase of 0.3 millivolts at the elastic limit, and an increase of about 4 millivolts at the point of rupture. For iron and steel he finds much larger values.

Both Walker and Dill and Richards and Behr, on the other hand (loc. cit.) come to the conclusion that, although there is an increase in the e.m.f. of iron (they did not work with other metals) caused by application of stress up to and beyond the elastic limit, it is so small as to defy measurement. They explain Hambuechen's results on iron as having been due to the hydrolysis of the ferric salt, which he used as electrolyte.

In the measurements made by the author use was made of two electrodes of the same material, and in the same condition. One of these could be stressed, the other served as a comparison electrode, measurement being made in each case of the difference of potential between the two.

These were immersed side by side, in a solution contained in a large glass tube, with stopper at the bottom, the solution being contained between a layer of paraffin below (to which was sometimes added a slight amount of carbon tetrachloride) and a layer of a transformer oil above. These precautions were taken to prevent oxygen from the air from affecting the e.m.f.

¹ Leon, Über die Spannungsveränderung in einer halbeisenformigen Kerle, Österreichische Wochenschrift für den öffentlichen Handel, Vol. 24, 1908, p. 43.

² Hambuechen, The Corrosion of Iron, Bull. Univ. Wisconsin, 1910, No. 8.

³ T. Richards and Behr, The e.m.f. of Iron Under Various Conditions, Publ. Carnegie Inst., 1906, No. 61.

⁴ E. Heyn, Materialienkunde, p. 376.

⁵ Walker and Hill, The Effect of Stress on the e.m.f. of Soft Iron, Trans. Amer. Electrochem. Soc., Vol. VII, 1907, p. 153.

The arrangement is shown in the sketch, Fig. 1. The potential measurements were made by a potentiometer. It was found necessary to protect the electrodes from light during measurements by wrapping black cloth around the container.

The material used in the tests was a homogeneous alpha brass of the following composition:

Copper	67.5 %
Zinc	32.5 %
Tin	—
Lead	0.06%
Iron	0.02%
Manganese	—

which was most kindly furnished by the American Brass

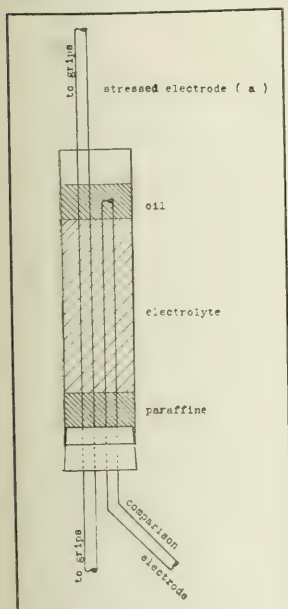


FIG. 1—DISPOSITION OF ELECTRODES

Co. in the form of $\frac{1}{4}$ -in. rods. Before the tests, this material was annealed at 400 deg. C. for an hour in order to relieve any initial stress, and the surface thereupon prepared by light rubbing with fine emery paper, followed by etching with nitric acid, washing and drying.

The test procedure consisted in placing the specimens in position, with the electrode (a) under zero stress, noting from time to time the e.m.f. between (a) and (b), then applying a stress, in units of 10,000 lb. per square inch, again noting during a certain period of time the

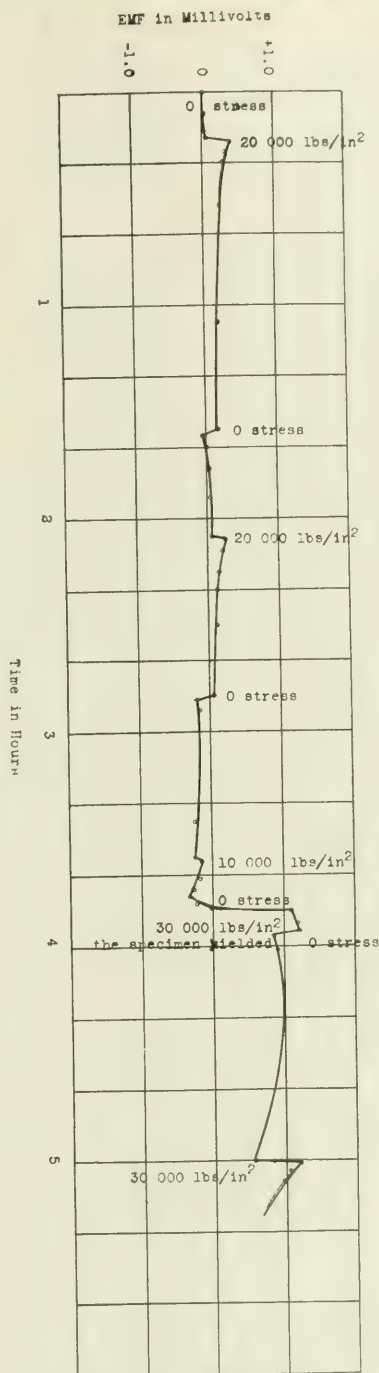


FIG. 2—THE E. M. F. OF STRESSED TO UNSTRESSED BRASS IN A SOLUTION OF $N/10 \text{ CuSO}_4 \cdot \text{ZnSO}_4$.

The + sign indicates that the bar under stress is electropositive to the comparison electrode.

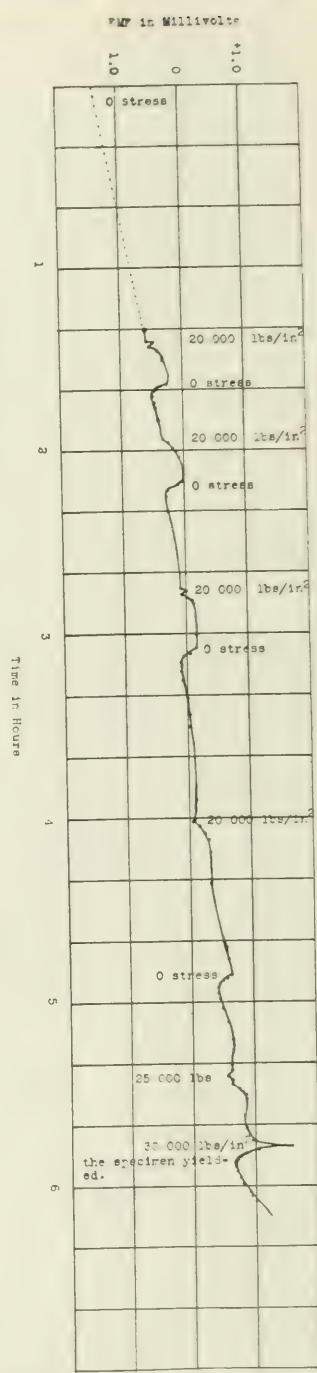


FIG. 3—THE E. M. F. OF STRESSED TO UNSTRESSED BRASS IN A SOLUTION OF $N \text{ ZnSO}_4$.

The + sign indicates that the stressed bar is electropositive to the comparison electrode.

e.m.f., removing the stress, noting the e.m.f., reapplying the stress, etc. The results of these measurements are best studied in the form of a curve, giving the e.m.f. as a function of the time, a change of stress being noted on the curve. Two such curves showing typical results obtained are given in the Figs. 2 and 3.

It is seen that there is a small but unmistakable increase in the e.m.f., due to the application of stress, and that this becomes relatively quite large, in Fig. 2, when the yield point of the brass is reached.

It is now to be noted that when a bar of metal is subjected to a tensile stress, a lowering of temperature takes place, and this lowering of temperature itself produces a momentary change in e.m.f., which often masks the permanent one. This effect can be noticed in the curves, and it is for this reason that the author adopted the method of holding the specimen at a constant stress for some time, and noting the e.m.f., instead of using Hambuechen's method of continually increasing the stress during the course of the measurements.

CONCLUSIONS

It is believed that an increase in e.m.f. of alpha brass to solutions containing zinc and copper ions, caused by the application of tensile stress, has been indicated and measured. This amounted to about 0.2 millivolts for 20,000 lbs. per square inch (below the elastic limit) and to about 1 millivolt at the yield point of the material, 30,000 lb. per square inch.

This value is apparently much greater than would be calculated for elastic stresses from thermodynamic considerations. It agrees well with values calculated for stresses above the elastic limit. The author does not wish at present to discuss this divergence, otherwise than to point out that the e.m.f. measured may be that at some point of the surface, e.g., at the bottom of a small notch, where the fiber stress is much greater than the average. In that case these results could be brought into agreement with thermodynamic theory.

An explanation is given of the effect of corrosion on brass under stress, in decreasing the ductility and strength, and which is based upon this fact of the increased e.m.f., and therefore corrodibility of brass under stress. At the bottom of small furrows in the roughened surface the stress is greater than at ridges immediately adjacent; a galvanic couple is formed, and the bottom of the furrow only is corroded, forming in time a crack, which becomes narrower and sharper as it penetrates inward, finally so reducing the cross section that fracture occurs.

This conception of the cause of the embrittling effect of corroding agents on brass under stress is borne out by the examination of samples which have been subjected to Jonson's test. In such samples not one but several fissures appear, narrowing down and becoming microscopically fine as they penetrate farther and farther into the interior of the specimen.

It may be noted in this connection that these fissures appear to favor the beta constituent and to avoid the alpha in a brass, such as manganese bronze, containing both of them.

The question as to why brass should be so susceptible to this effect and not also iron and steel (apparently at least) cannot at present be adequately answered, not indeed until further investigation has considerably increased our knowledge concerning the values of the stress-e.m.f. effect in these materials, the relative significance of this effect in comparison with other local e.m.f.'s (due to oxide and slag inclusions, etc.), the effect of the covering of corrosion product formed, and other points.

Other things being equal, the effect produced by a

corroding solution having a low conductivity will apparently be greater than that of one of high conductivity, since it allows greater prominence to those local stress e.m.f.'s between portions of the material immediately adjacent; it is known, for example, that nitric acid does not produce cracking in initially over-stressed brass in the manner in which ammonium hydroxide or mercurous nitrate or chloride does.

Bureau of Standards,
Washington, D. C.

Blast Furnace Products

BY J. E. JOHNSON, JR.

The products of the blast furnace may be divided into four broad classes, which in the order of importance and tonnage produced are steel-making irons, foundry-irons, puddling irons, and ferro-alloys. These classes are each subdivided into several subclasses. Steel-making and puddling irons and ferro-alloys depend entirely upon their analysis in the ordinary elements for their qualities, but foundry irons are required to have certain physical properties also. These physical properties, as will be shown presently, depend upon their content of certain elements for which we have only recently begun to analyze, and, therefore, their qualities are commonly not specified in terms of analysis in these elements, but in terms of analysis in the ordinary elements and physical properties combined. These relations are complicated and difficult; they require an article to themselves, therefore, the present article will be confined to the description of the other three classes of furnace products.

The Controlling Elements

The elements which are always present to some extent and whose quantity controls the qualities of iron as regards chemical specifications, are the same as those given in the article on "burdening," silicon, sulphur, phosphorus, manganese and carbon. In addition to these elements, there are present occasionally other elements, chromium, nickel, arsenic, etc.

In some of the earlier works on metallurgy, analyses of pig-iron were given showing appreciable quantities of calcium, aluminium and magnesium, but it seems safe in the light of our present knowledge to say that these were reported in error, since it is now absolutely certain that these elements are none of them reduced, or at least dissolved in the iron, by the action of the blast furnace.

Steel Making Irons

These may be broadly subdivided into two classes—acid and basic, so-called from the fundamental nature of the steel-making process in which they are applied.

In the acid processes, the lining of the steel-making vessel is silicious, and no bases such as lime or magnesia can be added to the charge because the presence of such bases would result in scouring out the acid lining of the furnace. The phosphorus cannot be removed except in the presence of a strongly basic slag, and these processes consequently do not remove any of the phosphorus in the original charge. Therefore, the phosphorus in the pig-iron must not only be as low as the desired phosphorus content of the steel, but must actually be lower because the phosphorus all remains while the other metalloids are almost wholly removed, and some of the iron is oxidized and lost in the slag during the conversion process, so that the weight of the steel produced is less by several per cent than that of the iron charged, and the constant quantity of phosphorus accordingly becomes a higher percentage of this reduced weight.

In the basic steel-making processes, on the other hand, the lining of the vessel is made of basic or neutral ma-

terials so that basic fluxes in sufficient amount may be added to the charge, and by the presence of these, the phosphorus may be removed down to almost any limit desired.

The maximum limit for phosphorus in any ordinary steel is 0.09 per cent, and, therefore, the maximum phosphorus in acid steel-making iron is about 0.08 per cent. In many varieties of steel, the allowable phosphorus is much lower and the phosphorus in the iron must be correspondingly lower.

In basic steel-making irons, on the other hand, the phosphorus may theoretically rise to any percentage without preventing the conversion of the iron into good steel, and actually does rise to 2 per cent and over in some steel-making irons in regular use in European practice.

No attention is paid to the carbon in any steel-making iron, either acid or basic, and it need not be mentioned again in connection with these irons.

Irons for Acid Steel Making

The three principal varieties of these are standard (acid), bessemer, acid open-hearth and "baby" bessemer.

Standard Bessemer

Up to a few years ago the acid bessemer process was the predominating process for the manufacture of steel in this country, but about twenty years ago the basic open-hearth process began to assume greater and greater importance until now bessemer steel is relegated to a bad second in the race. Practically all rails were formerly made of bessemer steel, but the superior quality which can be obtained with open-hearth steel has forced the abandonment of bessemer material for this service, and bessemer rails now made are only an insignificant portion of the total rail tonnage. The principal uses left for bessemer steel are for the manufacture of welded steel pipe, for which it is distinctly better than open-hearth, and sheet bar for rolling into tin plate. Some bessemer billets for drawing into wire are also made. The phosphorus specifications in these different classes of material vary, but normally the upper limit is 0.09 per cent so that the upper limit for the pig-iron for conversion into this steel is about 0.08 per cent. In some special cases higher phosphorus than this is permitted, and in many other cases somewhat lower phosphorus is specified.

SULPHUR SPECIFICATIONS

Sulphur, like phosphorus, is not removed at all by the acid processes, and, therefore, the sulphur in the pig-iron must be somewhat lower than the amount desired in the steel for the same reason as given for the phosphorus. As a general thing the sulphur specification for standard bessemer iron is under 0.05 per cent. It generally averages somewhat below this in good practice, while in some cases the steel makers desire it somewhat higher, though not much is said about this because sulphur has deservedly a bad name in the metallurgy of iron.

SILICON SPECIFICATIONS

The silicon in standard bessemer ordinarily runs from 1 to 1.5 per cent. This depends somewhat upon the bessemer practice and the class of steel being made. A certain amount of silicon must be present to give the heat required in the bessemer blow, while too much leads to excessive blowing time and too hot steel.

MANGANESE

The manganese requirements of standard bessemer are not very strict. Iron can be successfully used running very low in this element, and it can also be used up to 1.5 per cent or even higher, but the manganese burns

out during the blow, and combining with the silicon makes a very thin slag, the effect of which is to produce what the steel men call "sloppy heats," and manganese is not desired much above 1 per cent on this account. On the other hand, there is a growing belief in the steel business that the best steel cannot be made without the presence of a certain amount of manganese to prevent over-oxidation of the iron, and it is doubtful if an iron running 0.25 manganese, in the long run, would produce as good steel as one running 0.75 per cent.

Iron for the Acid Open-Hearth

The quality of the product of the acid open-hearth furnace is in some way not fully understood better than that of the basic open-hearth for some purposes. Special forgings, springs, and especially steel castings can be made to much better advantage from this material than from the basic open-hearth, so it is considerably used in spite of its higher cost. In particular material of this kind the phosphorus specifications are always low, generally around 0.04, and not to exceed 0.05. The iron for this process, therefore, must be down to about 0.03 or 0.035 in phosphorus to make the class of steel desired.

SULPHUR

The sulphur in this class of steel must always be kept low, usually below 0.04 per cent, and for this reason the sulphur in the iron must practically be no higher than the phosphorus, 0.03 to 0.035 per cent.

SILICON

The silicon specifications for this material are about the same as those for standard bessemer. The amount desired varies according to the practice and the conditions. Sometimes it goes as high as 2 per cent, but too much silicon requires a greater length of heat, and is, therefore, not desirable.

MANGANESE

Manganese specifications are not commonly given for this class of material. The considerations which control are very similar to those in the bessemer process, but the danger from sloppy heats does not exist and, therefore, the manganese can go somewhat higher than the acid open-hearth without being objectionable.

Iron for the "Baby" Bessemer

This process is only used in the production of steel castings, especially those of small size, and for this purpose the steel must be very hot in order to pour well into small moulds. Large heats of steel cannot be handled because it would be impossible to pour them quickly enough into a great number of small moulds, therefore, the bessemer vessel used is a small one, normally of about two tons capacity. In order to obtain the high temperature necessary, the converter is almost always side blown instead of bottom blown. Phosphorus specifications are practically the same as in the acid open-hearth, 0.04 or 0.05 and under. The loss is considerably heavier in this process than in the acid open-hearth, and, therefore the phosphorus tends to rise much more in the conversion so that the phosphorus in the iron must be at least as low as in the acid open-hearth, 0.03 or 0.035 per cent and under.

SULPHUR

The sulphur specifications for this iron have to be more rigid than those for the acid open-hearth because the iron must be melted in a cupola for introduction into the converter, and always picks up an objectionable quantity of sulphur in this remelting so that it is very difficult for the steel founder to meet the rigid sulphur specifications without having a very low sulphur iron to begin with. Therefore, iron for this process is desired

0.025 or under in sulphur, though it may be accepted as high as 0.035.

SILICON

In order to give the high temperature desired, iron for this process must have a high silicon content, never less than 2 per cent, and ranging up to 3 per cent and over. The burning of this silicon in the converter supplies the heat necessary to bring about the high temperature desired.

MANGANESE

There are no manganese specifications for this iron. Much of it is made and used very low in this element, being made from magnetite ores, but it is extremely doubtful whether this is as desirable as an iron containing a considerably larger quantity of this element, for the reasons already given.

Iron for Basic Steel Making

The basic processes for making steel are in a broad way similar to the acid processes except as to the character of the vessel-lining used, the vessels used being the bessemer converter and the open-hearth furnace as in the acid processes. The "baby" bessemer is not used with a basic lining for reasons not pertaining to the blast furnace, so they need not be discussed here.

When a basic lining is used, a condition is brought about altogether different from that involved in the use of the acid processes. In the latter the presence of silica, caused by the oxidation of the silicon in the iron, makes no difference because the lining of the vessel being acid, this silica has no effect upon it, but in the basic process this silica attacks vigorously the basic lining of the vessel even in spite of the bases added to the charge. The more silicon there is in the iron, the more silica is produced, and the more extensive is the damage done by its inroads on the lining, therefore, the first consideration in irons for basic steel making is that the silicon shall be low. This, however, brings about other conditions, especially in the basic bessemer.

The heat necessary to raise the temperature of the molten iron to that of molten steel, some 400 degrees F., is derived principally from the oxidation of the silicon since the oxidation of carbon to CO, the chief product of its oxidation in the converter, generates but little heat above that required for heating the products of combustion, and the nitrogen which accompanies them, to the necessary temperature. A greater amount of heat is required in the basic bessemer process than in the acid, and when we lower the silicon our principal fuel for the production of this heat is discarded; this must, therefore, be made up by other fuels. The only ones available commercially are phosphorus and manganese, consequently irons for the basic bessemer process require phosphorus to the extent of 2 per cent or over, or when this is not available, manganese can be substituted for it to some extent. This process for making steel is not in use in the United States, and complete data concerning the latest practice in regard to it are not available.

Iron for the Basic Open-hearth Process

The principal specifications in regard to this iron are those in regard to silicon and sulphur.

SILICON

This element is always desired below 1 per cent for the reason already explained, and the universal specification for merchant iron of this kind is silicon 1 per cent and under, but when the steel works operate their own furnaces, they take iron running as high as 1.20 in silicon. In general, however, the iron supplied to the basic open-hearth furnaces average about 0.75 to 0.90 per cent silicon. It is not produced to average much

lower than this because with this amount the destruction of the furnace linings is not very severe, and it is practically impossible to produce regularly iron with lower silicon without either increasing the sulphur or the coke and limestone consumption of the blast furnace.

SULPHUR

The universal specification for merchant basic iron is sulphur under 0.05 per cent. Steel works take iron from their own furnaces up to 0.06 per cent. Part of the sulphur is removed by the basic slag, and there is no difficulty in making steel with sulphur 0.03 and under out of iron with sulphur 0.06. Nevertheless, if too much sulphur requires to be removed the cost of conversion goes up, consequently the specifications are held to the limits given.

PHOSPHORUS

The specifications in regard to phosphorus for basic open-hearth iron are very broad. Iron with bessemer phosphorus is sometimes used, and on the other hand, iron with phosphorus to 1.85 per cent is successfully converted into good steel. In this country many of the irons made in the South contain from 0.85 to 1 per cent phosphorus. These are successfully used in the basic open-hearth furnaces, but they are not regarded so favorably by steel makers as irons containing 0.3 to 0.4 per cent phosphorus or lower, since when the phosphorus rises above these limits the heats are apt to require longer for complete dephosphorization; this runs up the cost of conversion and so is very objectionable to the steel maker. Where the phosphorus rises much above one-half per cent, phosphoric acid becomes an element of appreciable importance in the open-hearth slag, and this being in the form of phosphate of lime may be made to give the slag a commercial value so that what was a liability may become an asset, but this subject can be better treated in connection with the duplex process.

MANGANESE

The manganese specifications for basic open-hearth iron are about as broad as the phosphorus specifications, iron being used from that only having a trace of manganese up to that having one and one-half per cent or more. Formerly but little attention was paid to this, but in recent years steel makers have come increasingly to believe in the protective action of the manganese in preventing the over-oxidation of the iron, and the tendency is consequently to specify manganese 0.15 per cent or higher.

Iron Used in Compound Processes for Steel Making

In a conversion of iron into steel, the bessemer process has the advantage of large tonnage per unit of steel-making capacity, and, therefore its plant cost is very low. The open-hearth process, on the other hand, has the advantage of better quality of material produced and of considerably smaller conversion losses because the oxygen for oxidizing the metalloids of the iron is supplied to a very considerable extent by iron ore charged into the furnace, and the iron of this ore passes into the bath and increases the yield. This is particularly true in regard to the removal of phosphorus, since the loss involved in doing this in the basic bessemer conversion is very high, 15. to 18. per cent.

In order to obtain the advantage of both processes, attempts have been made at various times during the last forty years to use one type of furnace for one portion of the operation and the other type for the remainder, transferring the metal from one furnace to the other. These combined processes known as duplexing or triplexing, according to the number of furnaces used, were never very successful until the de-

velopment of the enormous ladle handling cranes of the present day made the transfer a matter of a few minutes, and effected it in such large masses of metal that the heat losses were insignificant. This development has occurred only within the last few years so that the evolution of the compound processes for steel-making is by no means complete.

The iron for these processes has the least rigid specifications of any. Phosphorus may be present in any amount, and quite high sulphur can be eliminated without much expense. The silicon is eliminated in an acid-lined bessemer converter, so does no harm unless present in excessive amounts, when it merely increases the time required for blowing. This adaptability to a wide range of irons is one of the causes that has brought about the introduction of the duplex process so rapidly in the last few years.

SILICON

The silicon for this process is generally desired about the same as that in the bessemer process, because not only is the silicon eliminated in the bessemer converter, but the carbon is commonly blown down to between 0.15 and 1 per cent, so that the iron is converted into steel, except for the phosphorus, which is still in the material and remains to be eliminated. The silicon is wanted about the same as in the bessemer, so as to yield the heat to keep the metal molten at the high temperature corresponding to the removal of the carbon, about 1.20 to 1.50 per cent. This is the easiest and cheapest iron there is to make from the furnace-man's point of view, and this adds to the commercial desirability of the duplex process.

PHOSPHORUS, MANGANESE AND SULPHUR

Specifications for these are virtually the same as for basic open-hearth iron, and the same general considerations hold in regard to them. There enters at this point, however, the condition mentioned earlier concerning phosphorus.

The duplex process enables the slag resulting from oxidation of the silica to be separated entirely from that arising from the oxidation of the phosphorus. As a result the phosphoric acid in the slag can be raised to a very much higher percentage with this process than with the straight open-hearth process.

When a considerable percentage of phosphorus is present, the process may be so manipulated as to raise the phosphoric acid to a point where the slag becomes a commercial asset valuable in proportion to its content of this substance, and under these conditions it may well be that high phosphorus is more desirable than low, because it permits the production of a higher grade or a greater quantity of slag, valuable as fertilizer. I have no knowledge of cases in which the phosphorus has been deliberately raised on this account, but a condition in which this would be might easily arise, iron containing less than 1 per cent of phosphorus can be so handled for conversion into steel that a commercial fertilizer of very important value is recovered.

Iron for Puddling

This variety of iron was formerly of great importance, as puddling represented the sole means of converting cast iron into a forgeable product; wrought iron, and all the standard products now made of steel, such as rails, plates, structural material, wire, etc., were at that time made of puddled iron. This process has, however, in recent years declined to an insignificant fraction of its former greatness, due to the greater cheapness with which steel can be produced and the superiority of that material for most purposes.

In spite, however, of the predictions to the contrary,

wrought iron has not died out altogether, but has, on the contrary, in recent years rather arisen in public esteem for certain purposes. Its weldability is admittedly greater than that of steel, and for most forging purposes it is much preferred to steel on that account. Certain rolled products, moreover, are preferred by some consumers when made of wrought iron rather than steel. This is notably true in regards to materials which are required to resist rust, especially sheets for roofing and siding purposes and welded pipe. The makers of these products in steel have waged a vigorous warfare against the conviction that wrought iron was better, but these products continue to be made of wrought iron and sold at a price considerably higher than that of the steel products.

The specifications for "forge" iron are rather broad and not very definite.

SILICON

Iron puddles more easily when the silicon is low, but some of the best grades of puddled iron have always been made of comparatively high-silicon iron, No. 2 foundry. The "gray forge" iron, which was the established grade for puddling purposes in the old days, ran from about 0.75 to 1.25 per cent silicon.

SULPHUR

The sulphur specifications for this iron are not at all strict. Sulphur exercises a less objectionable influence on wrought iron than on steel, and it is probable that the sulphur in the gray forge of the old days ran ordinarily between 0.04 and 0.08 per cent.

PHOSPHORUS

This iron is notable from the fact that it is desired to contain a certain amount of phosphorus, about 0.3 to 0.4 per cent, and where it is made at the present time, open-hearth slag or some similar material containing phosphorus is charged if necessary to raise the phosphorus up to this point. Most of the phosphorus disappears in the puddling process, though good puddled iron may contain as much as 0.2 per cent of this element.

MANGANESE

There are no particularly definite specifications for manganese in this iron, but it is understood that the best results are produced when there is a moderate amount of this element present, between 0.5 and 1 per cent.

CARBON

With this iron, as with the steel-making irons, no attention is paid to the carbon.

Ferro-alloys

Various alloys of iron with other elements are made in the blast furnace. Formerly it was the only means for doing this, but the developments of recent years have shown that certain alloys can be produced to better advantage in the electric furnace, and that some others can be produced therein which the blast furnace cannot produce at all. This has to a certain extent narrowed the field of the blast furnace in regard to ferro-alloys.

MANGANESE ALLOYS

There are two of these, spiegeleisen and ferromanganese varying from each other only in their percentage of manganese. The former was the earliest developed and was largely used in the days of the bessemer process, especially in rail manufacture; it has been very largely superseded in recent years by ferromanganese.

Spiegeleisen takes its name from the fact that the

manganese carbide forms in large flat flakes, half as large as one's thumb nail, which shine like mirrors in the face of the broken pig. Spiegeleisen contains from 15 per cent to 30 per cent of manganese, depending principally upon the amount of the element present in the ore from which it is made.

The amount of carbon in this alloy varies from $4\frac{1}{2}$ to $5\frac{1}{2}$ per cent.

No attention is in general paid to the silicon in this material, although in some cases a special product, high in silicon—6 or 8 per cent—as well as in manganese, is produced. This is known as silico-spiegel.

Both these products should have as little phosphorus as possible. The bessemer limit is usually specified for them, but they may be used containing higher percentages if it suits the conditions of the steel maker in other respects; that is, if the phosphorus in his raw steel is low enough to stand the additional quantity brought in by the spiegel, and the price at which he can buy it is low enough.

Ferromanganese.—The standard alloy of this name contains 80 per cent manganese, about 5 to $6\frac{1}{2}$ per cent carbon. No attention is paid to the quantity of silicon. Phosphorus is permitted up to about 0.2 per cent in ordinary practice, the larger quantity being allowed on account of the fact that the weight of the ferrosilicon used is much smaller than that of spiegel, owing to the difference in the manganese contained.

Ferromanganese is often made containing smaller percentages of manganese than that given. The alloys still go by the name of ferromanganese when the latter element is as low as 40 to 50 per cent, but this is not as desirable, since this alloy is introduced in the solid condition sometimes preheated into the molten steel running from the converter or open-hearth furnace into the ladle. It is desirable that the amount of metal so introduced shall be as small as possible, so as to produce its chilling action on the bath and increase the certainty of its uniform distribution through the metal, and obviously the higher percentage of manganese in the ferro the smaller weight required.

These are very largely the same considerations which have brought about a substitution of ferro for spiegel. When the latter is used, the quantity required is so great that it cannot be introduced solid, but must be melted in a separate cupola and run into the ladle as a liquid. This is more trouble and is out of the question when low-carbon steel is to be made, because the quantity of carbon in proportion to the manganese is three or four times as high in spiegel as it is in ferro, and in order to introduce enough manganese into the steel with the former, more carbon would be simultaneously introduced than could be tolerated for some purposes.

FERROSILICON

There are two varieties of this material, blast-furnace and electric-furnace. In the latter, there are very high percentages of silicon—from 50 to 80 per cent, but these products cannot be made in the blast furnace. Blast-furnace ferrosilicon is practically never made with any more than 15 per cent silicon. The silicon in the ordinary grades varies from 8 to 14 per cent.

This alloy is notable for the fact that carbon is kept out of the iron by the rise of the silicon, as previously described. This action begins with about 4 per cent silicon. When this point is reached the carbon decreases to the point where the graphite flakes, instead of appearing continuous in the fracture of the iron, are separated by areas of white, and this action continues as the silicon rises.

The reduction of carbon and increase of silicon gives the iron a sort of greasy look, and irons containing

from 4 to 8 per cent silicon are called silvery irons, because their color is much lighter than that of normal irons. These irons are to some extent regularly made for foundry purposes, foundrymen using them to raise the silicon in a mixture otherwise too low. For such uses, of course, the phosphorus specifications are unimportant, but most of this is used in certain methods of steel manufacture, and therefore requires to be below the bessemer limit in phosphorus.

No particular attention is paid to the manganese in this metal.

FERROCHROME

Ferrochrome was formerly made in the blast furnace, but never as far, as I am advised, in America. I am informed on good authority that the maximum amount of chrome that could be introduced into the iron was 30 per cent, no heat obtainable being sufficient to raise it higher than this. The introduction of the electric furnace has brought about the production of alloys much higher in chrome and correspondingly more desirable, so that the blast furnace no longer competes in this field.

Statistics of Chilean Nitrate Industry

The nitrate of soda manufactured in Chile during the month of June, 1916, amounted to 5,153,701 Spanish quintals of 101.4 pounds, against a production of about 5,353,900 quintals in May of this year, 2,613,976 quintals in June, 1915, 5,752,929 quintals in June, 1914, and 5,101,301 quintals in June, 1913, according to *Commerce Reports*. Exports totaled 4,217,810 quintals, against 5,143,500 quintals in the preceding month, and shipments of 3,866,168 quintals in June, 1915, 4,053,186 quintals in June, 1914, and 3,649,624 in June, 1913.

These figures show that production and exportation are still on a large scale though not at maximum. At present exportations are materially influenced by the amount of ocean tonnage available.

For the twelvemonth ending June 30, 1916, both production and exports were 70 per cent greater than in the preceding year, but fell somewhat short of the totals for 1913-14 and 1912-13, as the following summary discloses:

	1911-12	1912-13	1913-14	1914-15	1915-16
Production	Quintals 54,372,965	Quintals 59,450,462	Quintals 62,322,617	Quintals 34,091,243	Quintals 57,715,614
Exportation	54,254,471	58,492,375	58,751,291	32,070,714	55,285,814
To Europe and Egypt	41,407,449	43,051,680	44,534,131	16,939,650	29,017,777
To United States	10,983,701	13,392,999	12,290,782	13,437,415	23,484,842
East coast	9,896,768	12,336,221	11,222,657	12,295,291	20,390,839
West coast	1,086,993	1,056,778	1,068,125	1,142,197	3,094,003

Prices in Chile have shown rather slight changes recently. For ordinary nitrate, or 95 per cent, the price has been around \$1.77 per quintal for immediate deliveries with prices \$0.02 to \$0.04 higher for later deliveries. The difference between quotations for refined and ordinary grades has increased and is greater than has been ruling during the past year. For 96 per cent grade of nitrate the quotation has been about \$1.90 per quintal for delivery during early future months. During the first part of July the market became less firm, and present prices are slightly lower than those just mentioned, though very few sales by manufacturers are announced.

Platinum in U. S. in 1915.—According to a U. S. Geological Survey report, crude platinum was produced in California and Oregon in 1915 to the extent of 741.91 oz. Platinum from refiners of platinum, gold, and copper, was 8665 oz. of which 1587 oz. was domestic.

Features of the New Copper Smelting Plants in Arizona*

BY A. G. MCGREGOR

During the past five years five new copper-smelting plants have been built and put into operation in the State of Arizona. The monthly copper output from these plants averages from 5,000,000 to 18,000,000 lb. Previously, there never was as much activity in the copper-smelting plant construction in the same length of time in all the rest of the world.

Naturally, in this amount of work, some new problems were met and new features in plant design and equipment developed. Some of these features are described in this paper.

Concentrate Hauling, Unloading and Sampling System

CONCENTRATE CAR

The International Smelting Company has provided at its plant at Miami specially designed cars for hauling the concentrates from the mills of the Inspiration Copper Company and the Miami Copper Company. The car has a bottom that is readily made tight to hold flotation concentrates and is quickly and cheaply unloaded. Figs. 1, 2 and 3 show views and details of the car.

The main feature of this car is the slot in the bottom throughout its length, which is closed by means of short planks that overlap like shiplap as shown by Fig. 1. At one end of the car an iron gate operated by a screw and hand wheel is provided, which clamps or presses the planks together, making the bottom tight. A removable tapered plug rests vertically over this gate when the loading of the concentrates at the mill commences.

A concentrate unloading pocket (Fig. 4) 180 ft. long is provided at the smelting plant, which has a conveyor belt running throughout its length underneath the track. To unload a car the vertical plug at the end of the car is lifted by means of a chain hoist which is supported by a trolley overhead. The gate at the end of the car is opened approximately 18 in. The removal of the plug leaves a hole down through the concentrates. The concentrates are poked through the hole from the top of the car until it is convenient for a man to stand on the bottom of the car and draw one of the slats in the bottom toward the gate end of the car. The concentrates are then raked down with hoes on their natural angle of repose, which is nearly vertical, until the next slat is partly uncovered, when it is pulled toward the gate end of the car. This operation progresses until the opposite end of the car is reached. The slats and the grooves supporting them are then carefully swept off and cleaned with a broom; the gate is screwed back, pressing the slats together, and the plug is lowered into place. The car is then ready to be taken back to the concentrator for another load.

CONCENTRATE SAMPLER

Fig. 5 shows diagrammatically the scheme used for sampling the concentrates. It will be noted that the conveyor from the unloading pocket discharges onto a shuttle conveyor (a tripper on the former conveyor could have been substituted for the shuttle conveyor, but it would not have handled the sticky concentrates as well). Buckets attached at their ends to chain belts are arranged to cut through the stream of concentrates as they are discharged onto the shuttle conveyor. The chains are driven and supported by sprocket wheels. The arrangement is such that at the highest point in their travel the buckets are in an inverted position. At this point they pass under a revolving shaft which has

*A paper to be presented at the Arizona Meeting of the American Institute of Mining Engineers in September, 1916.

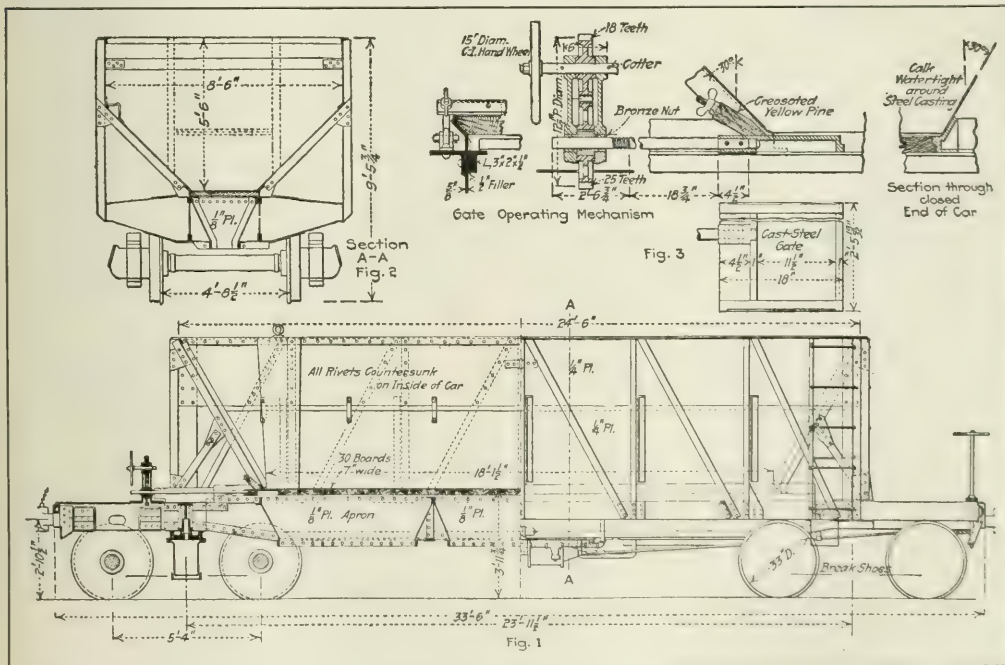


FIG. 1—6-TON CONCENTRATE CAR. FIG. 2—SECTION A-A OF FIG. 1. FIG. 3—GATE-OPERATING MECHANISM OF CONCENTRATE CAR

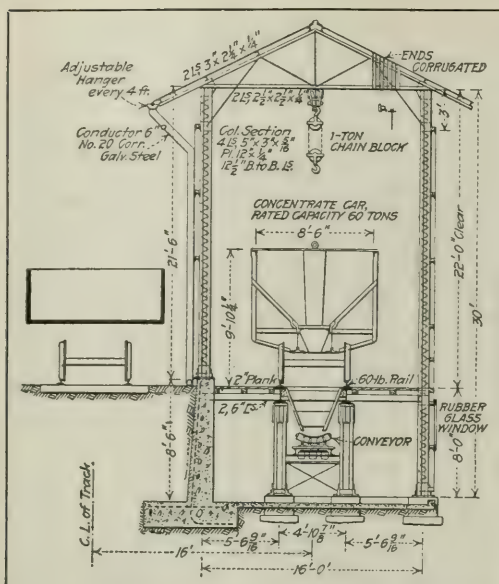


FIG. 4—SECTION THROUGH CONCENTRATE UNLOADING POCKET

a number of knockers, made of 6-in. belting, attached to it. These knockers slap the bottom of the buckets, jarring loose any concentrates tending to stick to them. This arrangement works satisfactorily on ordinary table and vanner concentrates, but is not satisfactory with flotation concentrates on account of the varying load on the conveyor belt, the flotation concentrates being unloaded from the car in large shunks.

BEDDING BINS

Fig. 6 shows a cross-section of the bedding bins used in connection with the concentrate car and sampler just described. The bins are 150 ft. long and have a total capacity of 9000 tons of charge. The concentrates are delivered by belts from the car-unloading pocket to any one of the three conveyors passing over the bins. Each belt has a motor-operated tripper, which travels back and forth throughout the length of the bin. Each tripper is arranged with two cross-belts, which discharge material on both sides of the tripper, instead of the ordinary chutes that would clog with the sticky concentrates. These cross-belts also permit of a wider top on the ore bed than could be obtained with ordinary chutes. The cross-belts of the tripper as well as the long belts running over the bins and all the other belts handling sticky concentrates are speeded to 400 ft. per minute, which aids in discharging the sticky material from the belt when it passes over the pulley at its head end or the pulley of the tripper. An oscillating deflector is so arranged that the material passing over the tripper is discharged, first, on one of the short cross-belts and then on the other. This is done to provide an even distribution of the material over the top of the beds, making the height of the bed on both sides of the tripper the same. The tripper is reversed at each end

of its travel by the reversal of its propelling motor through a magnet-switch control. The bins have "V" bottoms with a slot 2 ft. 4 in. wide running throughout their length. This slot is covered with short planks which are readily removed, and as the reclaiming progresses, they are merely moved back in the slot. The concentrates are raked down with hoes and allowed to discharge, through the opening in the bottom thus provided, onto the conveyor belts underneath. The concentrates are bedded in these bins with a proper amount of limestone and pyrite and the available secondaries, each bin comprising a bed. Storage bins for storing finely crushed lime rock, secondaries, pyrite, etc., are provided and arranged so that the fine material from these bins is delivered by a conveyor and discharged just ahead of the concentrates onto the belts leading up over the bedding bins. The material next to the bedding belts, therefore, consists largely of finely crushed lime rock, which is a further aid in the discharge of the sticky concentrates from these belts.

Roaster or Dryer Plant

Figs. 7 and 8 show end and side elevations respectively of the International Smelting Company's roaster or dryer plant. The main features of this plant consist in the method used for conserving the heat and in the placing of the Cottrell fume treaters directly above the furnaces. The roaster furnaces in this plant are used for drying the concentrates and are not used for roasting, as the charge contains no excess sulphur; in fact, it has been necessary to have some pyrite shipped in from Bisbee in order to raise the sulphur content of the charge sufficiently to prevent the production of mattes too high in copper for good clean slags.

CONSERVATION OF HEAT IN FURNACE

The furnaces are air-cooled. The cooling air, after passing through the furnace arms, is conducted up the central shaft to the top, thence down to the oil fireboxes connecting with the two lower hearths of the furnace. This gives preheated air for the combustion of the oil and conserves the heat absorbed by the cooling air. To further conserve the heat of the furnace, the linings are 12 in. thick. The outer 4 in. of lining, between hearths, is made of "Nonpareil" insulating brick. The manufacturers of these brick claim that 4 in. of their brick is equivalent in heat insulating value to 40 in. of ordinary brick. The tops of the calcine hoppers of these furnaces are insulated from the lower floor of the furnace building, just above them, by an air space. The calcine hoppers have non-conducting lining consisting of 2 1/4 in. of Nonpareil insulating brick and a 1-in.

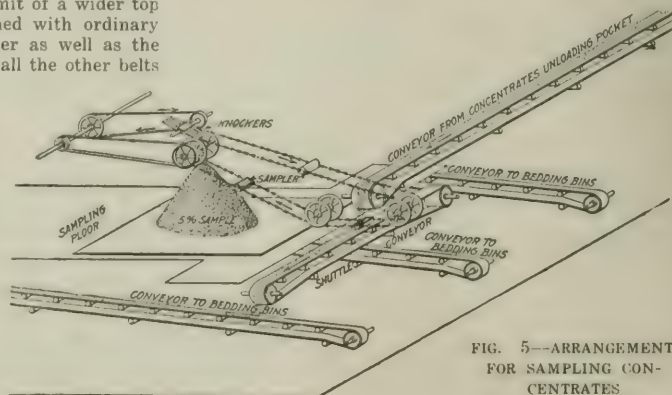


FIG. 5—ARRANGEMENT FOR SAMPLING CONCENTRATES

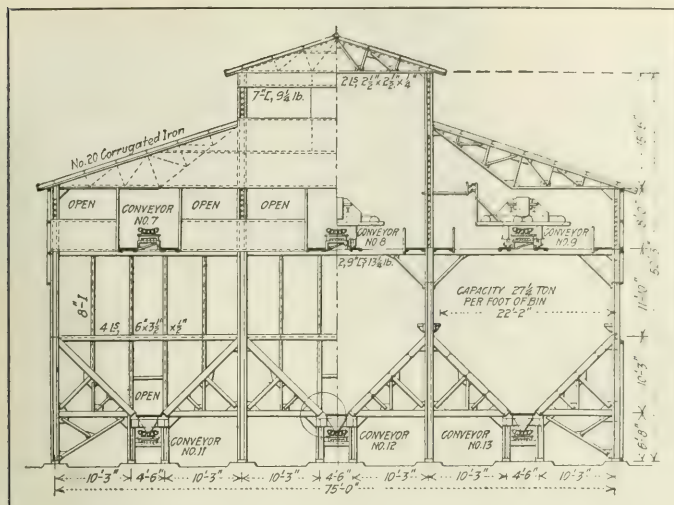


FIG. 6—CROSS-SECTION OF BEDDING BINS

layer of reinforced concrete. The reinforced concrete is to take the wear and erosion caused by the heated material inside the hopper, as the Nonpareil brick will not stand much wear or rough usage.

COTTRELL DUST-COLLECTING SYSTEM FOR ROASTER AND DRYER FURNACES

The Cottrell equipment for treating the gases from this plant consists of twelve units of twenty tubes each. The tubes are of lap-welded steel 13 in. in outside diam-

rising continuously from the furnace hearths to the outlet of the stacks.

Blast Furnace

Fig. 9 shows a general end elevation of the blast furnaces at the Calumet & Arizona Mining Company's plant at Douglas. These furnaces are 40 ft. long by 4 ft. wide at the tuyères. The ores and materials smelted in these furnaces are bedded so that the charge coming to the charge bins over the furnaces is thoroughly mixed. A coke bin and ore bin are provided on both sides of each

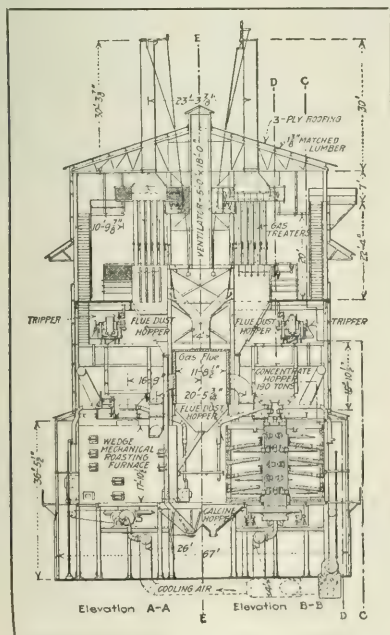


FIG. 7—END ELEVATION OF ROASTER AND DRYER PLANT, INTERNATIONAL SMELTING CO.

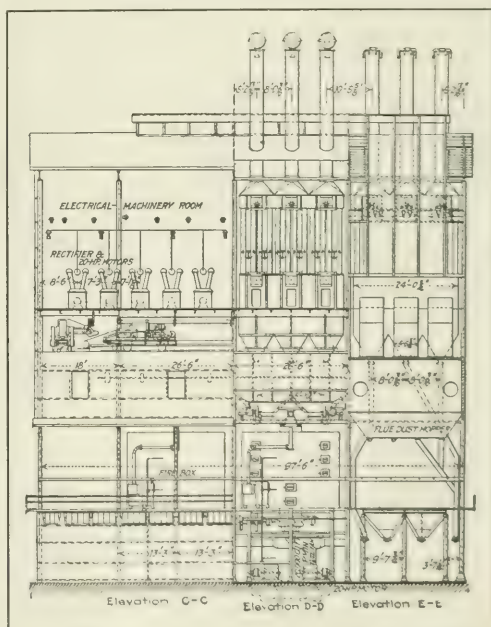


FIG. 8—SIDE ELEVATION OF ROADSTER AND DRYER
PLANT, INTERNATIONAL SMELTING CO.

eter and 15 ft. in length. They are flanged outward, or "Vanstoned" at each end, which reduces the brush discharge caused by sharp corners and makes a good means of connection to the upper and lower diaphragms. Suitable lugs are welded to the pipes against which the hammers strike when vibrating the tubes to shake off the collected dust. The electrical equipment for this installation is so arranged that the voltage used may be varied from 50,000 to 100,000 volts. The treater tubes were planned for a velocity of 5 ft. per second for the gases passing up through them.

The recovery of dust by this Cottrell treater system is practically perfect.

The main feature of this installation is in its arrangement, which permits the gases to pass directly up from the furnaces through the header flue, the tubes and the stacks, the gases

furnace. Each furnace has four charge cars, two on each side. The cars are 20 ft. long. When receiving a charge of ore or coke, the cars are resting on track scales. Each car has four compartments and the bins overhead have a gate corresponding to each compartment, so that the amount of charge for any part of the furnace can be regulated to suit the conditions. The car is propelled from the bins to the charging position at the furnace, a distance of 7 ft. or 15 ft. (according to whether a charge of coke or a charge of ore is being moved) by means of an electric motor geared to two wheels of the car. Fig. 10 shows a view of the charge car under the charge bins.



FIG. 10—VIEW SHOWING CHARGE CAR UNDER BINS

is carried into the beams by means of steel rods threaded at one end and flattened at the other. The flattened ends are riveted to the webs of the beams and a nut on the threaded end holds a lug against the bottom end of the jacket.

It will be noted that the furnace tops and charge doors are of structural steel in the form of air jackets. An air space is provided between the inner and outer sheets of the furnace tops. The lower end of this air space connects with the outside air while the upper end

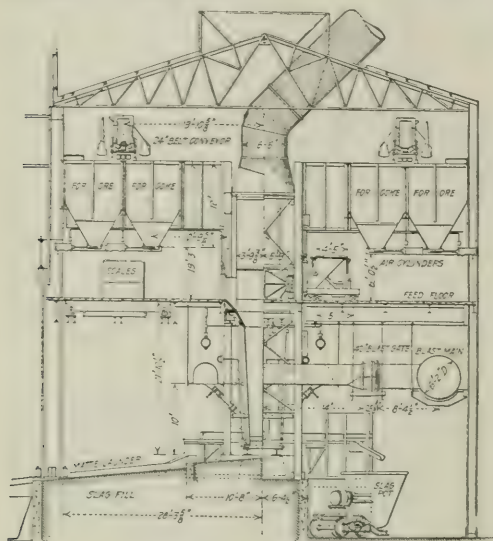


FIG. 9—SIDE ELEVATION OF BLAST-FURNACE PLANT, CALUMET & ARIZONA MINING CO., DOUGLAS

The furnace side jackets are in one length, 16 ft. 6 in. long and are 40 in. wide. It will be noted that the bustle pipe is combined with the truss or girder, which takes the outward thrust of the jackets at their midpoint. This simplifies the construction and gives more room around the bustle pipe for the water piping, etc.

Fig. 11 is a view showing the tuyères and bustle pipe.

The bridge plates for the furnace bottoms are of structural steel; $\frac{1}{2}$ -in. plates are riveted to 6-in. I-beams. The I-beams are spaced $12\frac{1}{2}$ in. apart. The cooling of the bottom is effected entirely by the surrounding air. The I-beams riveted to the plates undoubtedly increase the effectiveness of the cooling. The I-beams supporting the bottom are also used for holding the outward thrust of the bottom ends of the jackets. This thrust



FIG. 11—VIEW SHOWING TUYÈRES AND BUSTLE PIPE, BLAST FURNACE OF CALUMET & ARIZONA MINING CO., DOUGLAS

connects with the inside of the furnace top. The cool air is drawn in at the bottom and discharged at the top into the furnace gases going to the chimney, thus insuring a positive air circulation which keeps the sheets of the air top properly cooled. The furnace charge doors are jacketed in a similar manner.

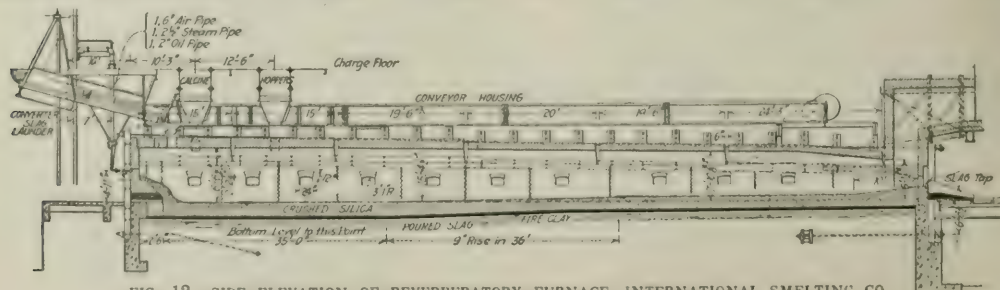


FIG. 12—SIDE ELEVATION OF REVERBERATORY FURNACE, INTERNATIONAL SMELTING CO.

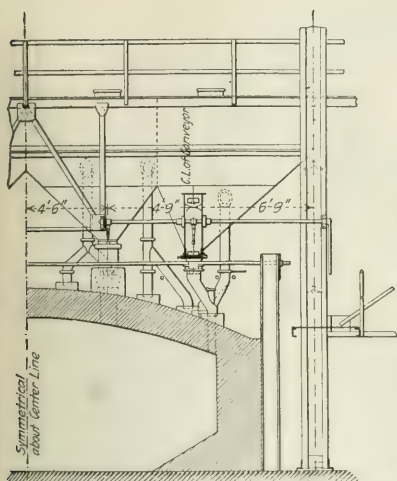


FIG. 13—SECTION REVERBERATORY FURNACE SHOWING CHARGING ARRANGEMENT

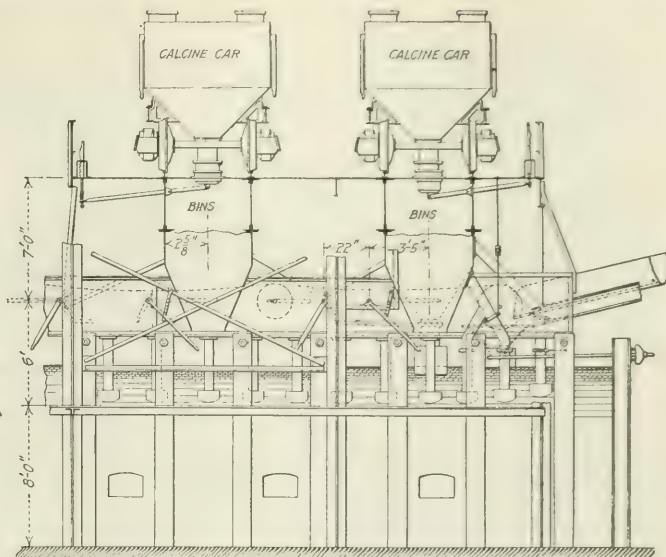


FIG. 14—LONGITUDINAL SECTION REVERBERATORY FURNACE SHOWING CHARGING ARRANGEMENT

These furnaces have been in use for three years, smelting as high as 1400 tons of charge each per day, and no repairs or replacements have been made in furnace water jackets and no warping has taken place in the air-cooled tops.

Reverberatory Furnaces

Fig. 12 shows a side elevation of a typical reverberatory furnace at the International Smelting Company's plant which has several features worthy of mention.

FURNACE BOTTOMS

It was especially desirable at this plant, on account of difficulties at another plant, to avoid any trouble with furnace bottoms in starting up. To accomplish this, broken slag was brought in railroad cars from the Old Dominion smelter and was melted in a small blast furnace, obtained by setting up a number of discarded furnace jackets and a motor-driven blower, on the site for the reverberatory furnaces. The molten slag thus obtained was conducted in launders to the foundations

of the reverberatory furnaces. Heavy concrete beams and struts were provided between the furnaces for taking the thrust from the lower ends of the buck stays. Later, the spaces between the concrete struts and the beams were filled in with molten slag obtained from the regular operation of the reverberatory furnaces. The slag bottom was covered first with a 4-in. layer of fireclay and then a 27-in. layer of silica (94 per cent SiO_2) crushed to minus $\frac{1}{4}$ in. These bottoms gave no trouble whatever in starting up.

FURNACE FETTLING AND CHARGING SYSTEM

The method of charging, instead of fettling only, along the side walls of reverberatory furnaces, now so successfully used by the Canadian Copper Company and the Anaconda Copper Mining Company, was developed after the construction of this plant was well along. The plant was laid out for charge tracks running at right angles to the furnaces near the firing end. In order to distribute the charge along the sides of the furnaces, charge hoppers were located under the charge

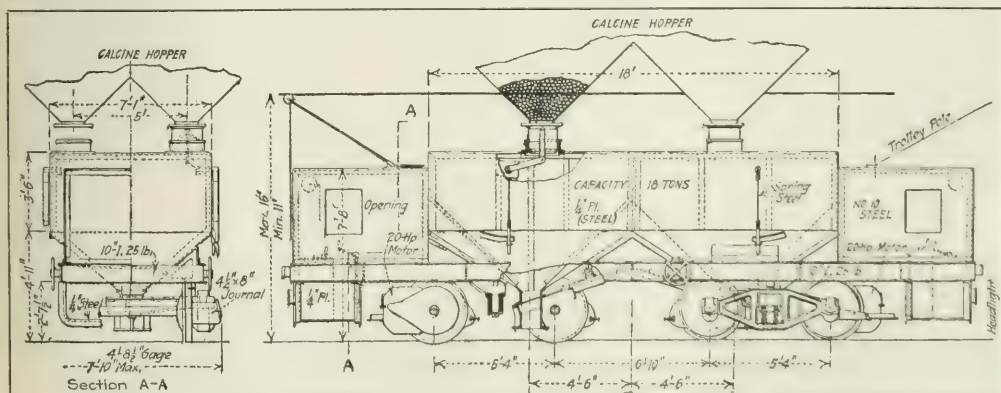


FIG. 15—END ELEVATION OF CALCINE CAR. FIG. 16—SIDE ELEVATION OF CALCINE CAR

tracks directly over the side walls of the furnaces. Drag-chain conveyors were installed, one over each side of each furnace, which received the charge from the charge hoppers (see Figs. 13 and 14). Under these conveyors, approximately every 30 in., suitable down-spouts with gates are provided so that the charge may be distributed along the side walls of the furnaces throughout their length. The bridge wall and side walls at the firing end of the furnaces are charged by drawing directly from the hoppers through suitable spouts.

The floor over the charge tracks around the skimming end of the furnace is paved with firebrick.

CALCINE CARS

Figs. 15 and 16 show end and side elevations respectively of the calcine car used at the International Smelting Company's plant. The feature of this car is the arrangement used for reducing dust losses in receiving and discharging a charge. The car is equipped with four sliding sleeves in the top which are spaced to register with the discharge openings of the calcine hoppers at the roaster plant. When the car is spotted under the roaster hoppers in its proper position, the sleeves are forced up against the calcine hoppers by means of levers on the side of the car. The operating lever is of flat spring steel so that the sleeve can be firmly pressed in contact with the flange at the bottom of the calcine hopper, and held there by a notch in a quadrant on the side of the car. The spring handle insures a good pressure between the sleeve in the top of the car and the flange of the calcine hopper regardless of the small variations in the distance between the top of the car and the calcine hoppers or any lost motion in the connection of the lever with the sleeve. An air vent is provided in the car made of fine woven wire mesh.

Fig. 14 shows the sleeves in the top of the reverberatory furnace charge hoppers for receiving the charge from the calcine car. These sleeves are similar to the sleeves in the top of the calcine car. By pressing down

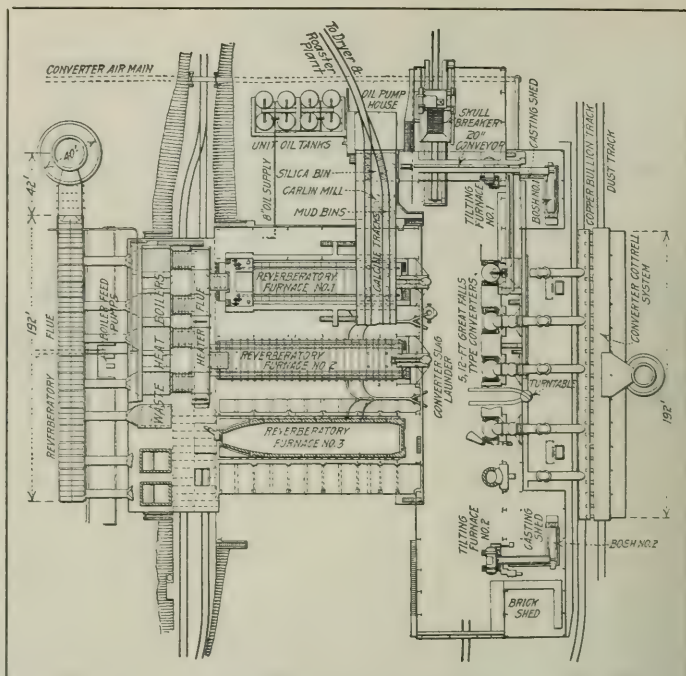


FIG. 18—PLAN OF INTERNATIONAL SMELTING CO.'S PLANT (A) SILICEOUS ORE-CHARGING DEVICE FOR CONVERTER

on the lever, which is operated from the charge floor, the sleeve is forced up against the flange of the discharge spout of the car. Notches are provided in the lever which engage a catch and thus hold the sleeves in their upper position while the car is being discharged. The pressure of the handle is transmitted to the sleeve, as will be seen from the figure, through a helical spring, so that a good contact between the sleeve and the spout of the car is assured regardless of the lost motion and wear in the operating levers and the variations in the distance between the sleeves in the charge floor and the flange on the discharge spout of the car.

BAFFLING IN WASTE-HEAT BOILERS

By reference to Fig. 17, it will be noted that the header flue between the reverberatory furnaces and the

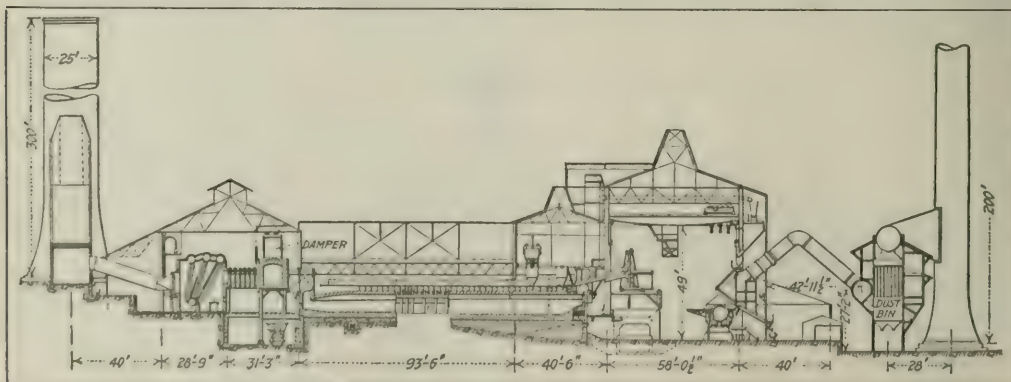


FIG. 17—TYPICAL CROSS-SECTION OF THE INTERNATIONAL SMELTING CO.'S PLANT.

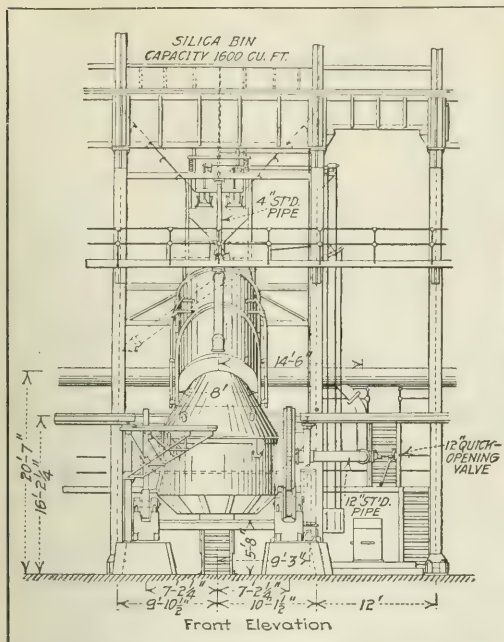


FIG. 19—CONVERTER PLANT, INTERNATIONAL SMELTING CO.

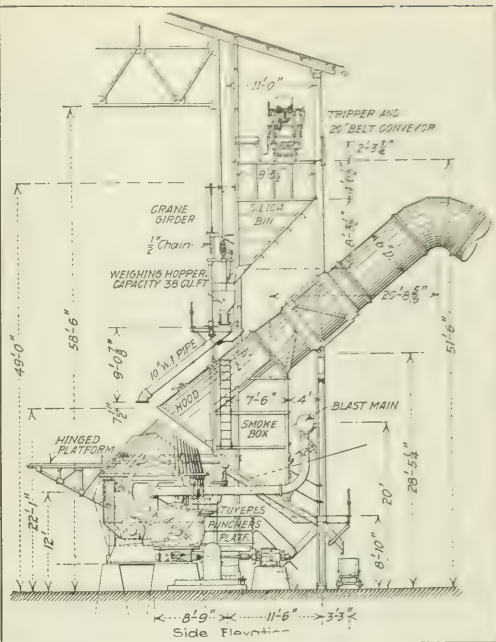


FIG. 20—CONVERTER PLANT, INTERNATIONAL SMELTING CO.

waste-heat boilers, and the connections between the header flue and boilers are well up above the furnace floor level, giving ample head room for the convenience and comfort of the workmen; the bottom of the header flue is 10 ft. 6 in. above the furnace floor level. Also, it will be noted that the boiler-room floor level corresponds to the furnace floor level. This is made possible by reversing the baffling in the Sterling boilers so that the gases enter the front of the boiler near the top and leave the boiler at the rear near the bottom instead of as in the standard setting.

This arrangement of baffling gives equally as good results from the standpoint of water circulation in the boiler, priming, etc., as the standard baffling.

Arrangement of Converter Plants

Southwestern practice is to have the converter plant adjacent to the reverberatory furnaces, arranged so that the reverberatory matte is received through launders, into ladles directly under the converter plant crane. Also they are arranged so that the converter slag may be poured from ladles by the converter crane back into the reverberatory furnaces through launders extending from the converter aisle to openings provided in the roofs of the reverberatory furnaces. The converter slag is usually discharged several feet in front of the bridge-wall of the furnace and midway between the side walls. Fig. 17 is a typical cross-section of the International Smelting Company's plant and is typical of the new reverberatory smelting plants in Arizona. Fig. 18 is a plan of the same plant.

Several of the plants are arranged so that the siliceous ore

for the converters is drawn directly from bins overhead. Figs. 19 and 20 show a typical arrangement of bin, measuring hopper and chute for accomplishing this operation. This particular arrangement is installed at the International Smelting Company's plant. A weighing or measuring hopper is interposed between the overhead bin and the chute leading to the converter mouth. The hopper is mounted on springs and is connected by levers and links to an indicator readily seen from the operating floor. Any desired amount of charge can be weighed out into the measuring hopper and discharged into the converter, and this can be accomplished entirely through the operation of levers on the main floor of the converter plant.

CONVERTER PLANT CRANES

Most of the newer plants are equipped with 12-ft. Great Falls type converters. These converters weigh,

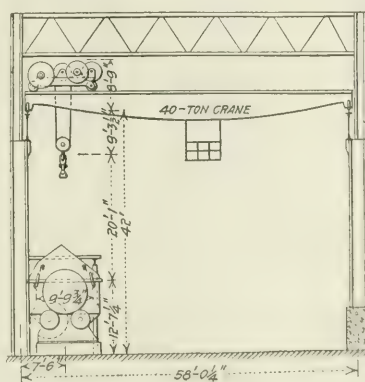


FIG. 21—METHOD OF LIFTING CONVERTERS, CALUMET & ARIZONA MINING CO.

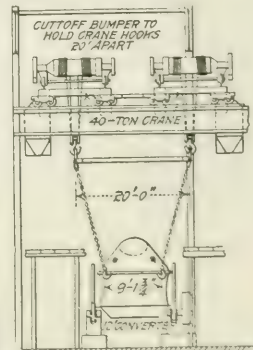


FIG. 22—METHOD OF LIFTING CONVERTERS, CALUMET & ARIZONA MINING CO.

Copper Company at Clarkdale, Ariz. It is 30 ft. 9½ in. in diameter inside the steel plates and is 400 ft. 1 in. in height, from the base to the top. It is believed to be the largest steel chimney in existence at this time. It has a brick lining 4 in. thick throughout its height.

SLAG FOUNDATION FOR STEEL CHIMNEY

Fig. 27 shows the details of the foundation for a steel chimney at the smelting plant of the Calumet & Arizona Mining Company at Douglas. The chimney is 305 ft. high from the top of the foundation and is 25 ft. 9½ in. in diameter inside of the steel shell. It has a hollow-tile lining 4 in. thick throughout its height. The feature of the chimney is in the construction of its foundation. The foundation was cast from molten slag hauled to the site for the chimney in the usual slag pots, instead of concrete or masonry, as is usual for chimneys of this type. A template for holding the anchor bolts was made of structural angles and channels supported on a central concrete pier, and held from turning or moving by a second concrete pier at the outer circumference. The foundation bolts were supported at their lower ends on small concrete piers and they in turn supported the template at other points of its outer circumference not supported by the concrete pier, each bolt having at the top a nut on the under side and one on upper side of the template, forming a secure support. Large washers were provided for the bottom ends of the anchor bolts, over which were laid old steel rails. Blast-furnace slag was then poured over the foundation and adjacent ground, forming the foundation for the chimney. A concrete capping was laid on top of the slag for the cast-steel base-ring of the chimney proper.

Warren, Arizona.

A New Thermo-Electric Method of Studying Allotropic Changes in Iron or Other Metals*

BY PROF. CARL BENEDICKS

In a closed circuit consisting of a homogeneous metal, no electromotive force, capable of causing a current, is produced, however the temperature of any part may be changed, according to Magnus.

If, however, the metal has an allotropic transition point (two-phase point), and some part of the circuit be heated, and remain at a stationary temperature above this point, the circuit can no longer be said to be homogeneous, as the hottest part, according to the assumption, corresponds with a new allotropic state—forming a new phase. However, even in this case, no electromotive force comes into play, as the differences of potential, which *a priori* may be assumed to exist between the two phases, equalize each other at the contact surfaces, on account of the equality of temperature of the contact surfaces.

If, on the contrary, the local heating be not stationary, there is always a possibility that the two contact surfaces may differ in temperature. Let us assume, as a special case, that the locally heated zone might travel with a constant speed along the conductor.

Now, it is known that the temperature of a given transition is always somewhat higher on heating than on cooling, which depends on the fact that a real allotropic transformation takes a definite time to perform in every case.

Thus the contact surfaces between the two phases, as

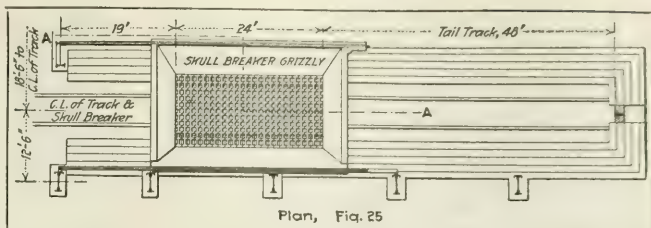


FIG. 25—SKULL BREAKER, INTERNATIONAL SMELTING CO. PLAN

already stated, will have slightly different temperatures, and there is a possibility that a measurable thermoelectric force will come into action.

In fact, it was stated by F. T. Trouton,¹ as early as 1886, that a thermo-electric current is produced when an iron wire is moved through a flame, so that probably a local heating above 900 deg. may occur.

This phenomenon, which, though simple, affords a good lecture experiment,² was correctly explained by G. F. FitzGerald as depending on what Sir W. F. Barrett³ in an interesting note describes as thermo-electric hysteresis.

In the near relation to this effect an observation made shortly before by H. Le Chatelier⁴ on silver iodide bears closely on the same point. The substance was enclosed between two metal electrodes, the circuit thus consisting of two different conductors. It was found that at the transition point strong electromotive forces appeared, which primarily were to be ascribed to a thermo-electric action.

It was proposed by Le Chatelier to take advantage of this phenomenon for the study of allotropic transformations. At his suggestion, O. Boudouard⁵ made some determinations on nickel steel. Le Chatelier⁶ himself published some curves for special steels obtained by this method (platinum wires were fixed at the ends of a short steel specimen, and the electromotive force between them was observed on ordinary heating or cooling).

This method, however, has not been generally accepted, probably on account of a serious inconvenience already pointed out by Le Chatelier. In fact, the electromotive forces which come into play with this arrangement (using an immovable, bimetallic specimen) are occasioned by the inevitable, totally uncontrolled local temperature variations of the furnace, with the consequence that even "the direction of the current observed at the very moment of transition may change with each experiment."⁷ Thus, if the temperature degree of a transition point can be determined by this method, every quantitative conclusion as to the intensity of the transformation seems to be excluded.

It might now be asked whether it is not possible to overcome this inconvenience and to find a quantitative method, if, according to the foregoing explanation, a local heating, traveling with uniform speed along a wire, is made use of. It has occurred to the author, first, that this might furnish a quantitative method for ascertaining the existence of allotropic points in the metal (two-phase allotropy); further, that this method might possibly give useful information even in the case of an inner molecular equilibrium, changing with temperature (one-phase allotropy). In fact, the molecular changes

¹Proceedings of the Royal Dublin Society, 1887, vol. v.

²The flame, which may possibly cause some chemical alteration, can then be conveniently replaced by a small electric heating device.

³Transactions of the Royal Dublin Society, 1900 (2) vol. vii, p. 27; Philosophical Magazine, 1900 (5), vol. xlix, p. 309.

⁴Comptes Rendus, 1886, vol. cii, p. 317.

⁵Revue de Metallurgie, 1904, vol. i, p. 80.

⁶Ibid, p. 134.

⁷Ibid, p. 133.

*A paper presented before the (British) Iron and Steel Institute.

even in this case probably take some definite time to occur, and the equilibrium, at a given temperature, ought not to be quite identical on heating and on cooling; thus generally a thermo-electromotive force should come into play, even though only single phase is present.

Since, according to the theory advanced by the author,⁶ and lately treated in a careful way by K. Honda,⁹ such a one-phase allotropy interval exists below the two-phase point A3, it seems to be of special interest to study iron by this method, especially at the temperature interval below A3.

Experimental Arrangement

According to the principles explained above, the experimental arrangement was a very simple one (Fig. 1), as follows:

The metal wire AA' to be studied moves through a little electric furnace B, the maximum temperature of which is measured by a platinum-rhodium thermocouple, with a compensating arrangement C (St. Lindeck and R. Rothe). The free ends of AA', at F (a point constant temperature) are connected with the copper wires leading to a mirror galvanometer G.

The central part of the wire, AA', is stretched by two strings, running over a horizontal wheel E and two

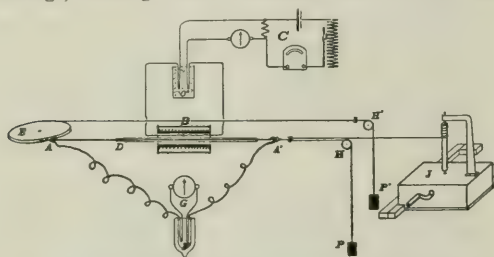


FIG. 1—ARRANGEMENT OF EXPERIMENTAL APPARATUS

small vertical pulleys H, H', and loaded with the weights P, P'. A uniform motion is communicated to AA' in the one or the other direction by a third string, which is wound on a cylindrical drum by the watchwork J (gramophone movement); by suitable guides I is easily brought into line with the string at H or at H'.

The wire AA' was sufficiently protected against oxidation by passing it through a fixed silica capillary tube D.

The furnace being heated to a suitable temperature, the deviations of the galvanometer G were read with AA' moving first in one and then in the other direction. The half of this difference in millimeters is given as the deviation U.

The sensibility of the galvanometer (resistance about 100 ohms) was such that 1 mm. corresponded to 5.6×10^{-6} volts.

The value of the electromotive force resulting must be influenced by several factors, not taking into account the nature of the material itself and the temperature, namely, (1) the speed of displacement, (2) the section of the specimen, and (3) the temperature distribution in the furnace.

1. Smaller variations in the speed of displacement were found to have very little influence, except for the purest iron. A constant speed of 1.6 mm. per second was adopted throughout.

2. The diameter of the wire especially investigated was 1.01 mm. Owing to this thickness a load P, P', amounting to 12.5 grams, could be used, which was enough to secure uniform displacement of the wire.

As will be seen from Series I and II, on the one hand, and III, on the other, the influence of the diameter of the wire is probably very slight.

3. In order to obtain an idea of the temperature distribution of the heated zone through which the wire had to pass, the mean of the observations of the temperature T at different distances X from the middle of the furnace is given as follows:

This distribution is graphically shown in Fig. 2.

Material Used

The iron selected for investigation was obtained in April, 1912, from the Kohlsua Ironworks. It contains

Distance X, Millimeters	Temperature T, Degs. Centigrade
+50	300
40	587
30	797
20	848
+10	857
0	858
-10	859
20	837
30	710
40	410
-50	255

0.10 per cent of carbon, but is otherwise of remarkable purity, as shown by the following analysis, performed at the Kohlsua laboratory:

Carbon	Silicon	Manganese	Phosphorus	Sulphur
0.10	0.14	0.03	0.26	0.007

Delivered as rolled wire 5.2 mm. in diameter, it was further drawn down to the diameter mentioned of 1.01 mm. at the wire works of the Nya Garphytte Fabriks Aktiebolag, Latorps Bruk.

Since for the special control Series III a thinner wire was desirable, the author drew the wire further in an ordinary drawing-plate. On this occasion the apparently very interesting observation was made that this material—obviously on account of its great purity—could be directly drawn through the finest hole of the plate, 0.23 mm., and further in sapphire holes to 0.09 mm., without the slightest annealing and without any real hardness being produced by this severe cold-working. This fact

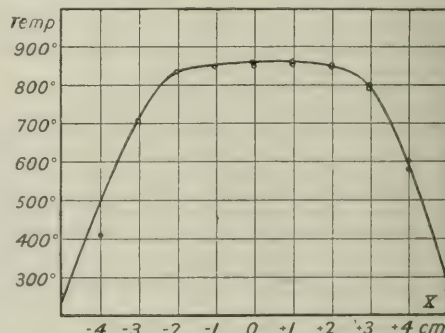


FIG. 2—TEST CURVES

seems to prove that iron of a high state of purity, even at 0.10 per cent carbon, has considerably more "liquid inner friction," and considerably less "solid inner friction,"¹⁰ than has been generally believed, even in view of the extremely high mechanical deformability of pure iron in A3, found by the author two years ago.¹¹

It can be questioned whether this extremely high soft-

⁶Journal of the Iron and Steel Inst., 1912, No. 11, p. 242; 1914, No. 1, p. 407.

⁹Ibid., 1915, No. 1, p. 159; Sci Reports of the Tohoku Imperial Univ., 1915, vol. 1, p. 169.

¹⁰By H. I. Hannover, Mekanisk Teknolog, 11, 3 Ed., Copenhagen, 1915, footnote, p. 68.

¹¹Journal of the Iron and Steel Institute, 1914, No. 1, p. 431.

ness¹² of pure low-carbon iron is favorable to the well-known Beilby hard amorphous state theory.

Since it was highly desirable to make experiments by this method on still purer iron wire, which was, however, not available, the following method was tried and found to be practicable. A small thin specimen of the extremely pure electrolytic iron used by Drs. J. E. Stead and H. C. H. Carpenter,¹³ kindly presented by Professor Carpenter, was carefully rounded off at the corners, after which a strip about 1.3 mm. broad and of sufficient length was cut off round the piece. This strip was straightened and strengthened—especially against oxidation—by forming it into a U section.

Experimental Results

Determinations at a given temperature showed no difference when made during heating or cooling of the furnace, as was to be expected.

A blank experiment was performed with a 1-mm. copper wire in the same interval of temperature as that

Temperature T, Degrees Centigrade	Deviation U in Millimetres	Mean
642	+ 1.9 - 0.3	1.1
708	5.1 1.2	3.2
75	18.7 18.5	18.6
810	21.2 23.4	22.3
854	64 61	63
873	84 88	86
888	96	94
925	102	100.5
950	...	110

finally used. After a first annealing no deviation of the galvanometer whatever was obtained, which agrees with the known absence of allotropic change in this metal.

The result of the first series (I) of experiments on the Kohlswa iron wire is given in Table I.

These determinations are reproduced graphically in Fig. 3 as small circles.

It will be seen that this thermo-electric hysteresis effect is already sensible somewhat above 600 deg.; other determinations not given here seem to corroborate this lower limit, though in a somewhat uncertain manner. The effect increases with increasing velocity, as it seems, up to about 875 deg., where an increase at constant rate sets in, corresponding with the γ range. It may be said that A3 is clearly shown by a discontinuity.

This first series, however, is not sufficiently accurate to enable it to be decided whether between 600 deg. and 875 deg. the increase is a continuous one, or whether there might be a discontinuity at A2 (768 deg.). A

second series (II) was carried out between 700 deg. to 800 deg., marked by vertical crosses. The observed values do not show any discontinuity.

A third series (III) was performed on the same material drawn out to 0.30 mm. wire. Owing to the fact that the stretching weights were only 20 grams, the motion was less regular than before. It will be seen, however, that the observed points (diagonal crosses) do not differ much from previous observations. This indicates that the slight oxidation which occurred has no sensible effect on the observations, which also seems probable from other points of view, and that the diameter has but a slight influence.

A fourth series (IV) was executed on the strip of pure electrolytic iron, as mentioned above (shown by full circles). In this case, as might be expected from the known influence of impurities, the effect is generally much less strong than with the 0.16 per cent carbon iron; the difference is less pronounced at the highest temperature, where, of course, the γ state prevails even in the absence of every trace of impurity. In any case, in a qualitative way, the effect is the same.

It was rather interesting to find, consistently with the impurity effect just mentioned, that while for the iron with 0.10 per cent carbon the speed of the motion had but very little influence, for the purest iron the effect was stronger if the speed exceeded the normal value.

The total appearance of the curves is similar to the well-known dilatation curves (Charpy and Grenet), inasmuch as both obviously belong to the allotropy Type IIa. The new determinations have the special interest of proving the existence of molecular changes, demanding a definite time to occur.

It is scarcely necessary to point out that these new facts give additional support to the theory expounded by the author, that a continuous molecular change does

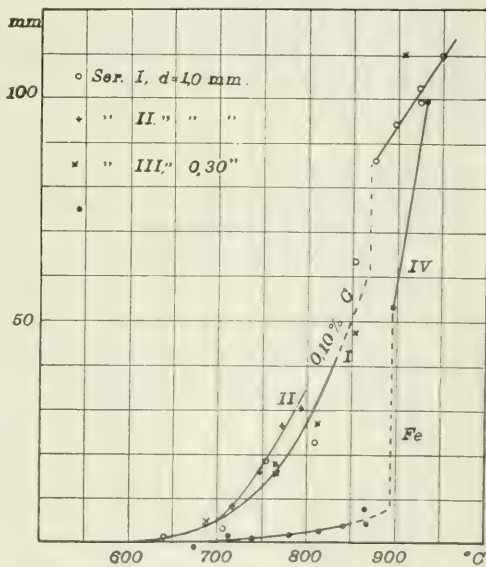


FIG. 3 TEST CURVES

occur in the alpha-phase at temperatures up to A3, or, in other words, that the alpha-phase has an increasing solubility for the molecules, or atoms, which are to be considered as characteristic for the gamma-phase. Whereas, A3 is a true allotropic point, where two phases co-exist, this is not the case with A2.

¹²In this connection it might be pointed out how important it is that laboratories, equipped with good technical-mechanical appliances, should be at the disposal of scientific men, offering the possibility of autoptic observations. Exactly the same 1-millimetre iron wire, on the request of Dr. Bengt Beckman, Upsala, was sent by me to the Cryogenic laboratory, of Leyden, where it was to be used for researches by Professor H. Kamerlingh Onnes and Dr. Beckman. This wire was drawn by Heraeus in Hanau to a diameter of 0.1 millimetre. If, in Hanau, some observations were made of the very peculiar viscosity properties of this iron, they apparently have not been reported to these authors (Comm. Phys. Labor., Leyden, No. 132, p. 7, 1913). At the Garphytte Works, the manager, Mr. G. Tidholm, found that this iron was so excellent for drawing purposes that inquiries were made as to whether it could be obtained in commercial quantities. It was only after having gained personal experience in the fine drawing of this material that the author could get some idea of this remarkable occurrence of "liquid inner friction" in iron which, according to a private communication, was likewise unknown to Professor Hannover, to whom a sample was sent.

¹³Journal of the Iron and Steel Institute, 1913, No. 11, p. 119.

On the other hand (and this might be the principal result), it has been found that a local heating, traveling with definite speed, constitutes a method which may be of value for allotropy investigations, not only for iron, but for other metals or alloys as well.

As for iron it would be highly desirable to use pure iron wire, of sufficient length and diameter, and to repeat the determinations with greater accuracy, and with greater velocity, than it was possible to do here, on account of want of material.

Summary

1. The principle is described, and an experimental arrangement is shown for a method of determining an effect of thermo-electrical hysteresis (Barrett) in metals, which are characterized by allotropy (both two-phase and single-phase). The metal to be investigated is moved, in the form of a wire, with constant speed through a small furnace, the maximum temperature T of which is known; between the free ends of the wire an electromotive force may appear, if molecular changes occur in the metal at temperatures below T .

2. It has been found that this thermo-electric hysteresis effect, for iron, shows a very marked discontinuity at A3 (Fig. 3). Above this point the effect is very strong, following a straight line, but it is also very considerable at lower temperatures, even as low as about 600 deg.

As might be expected, the effect is considerably stronger in iron with 0.10 per cent carbon than in carbonless iron.

No discontinuity corresponding to A2 could be found.

3. These experimental results give additional support to the theory of the allotropy of iron, as expounded by the author. However their accuracy is not very high, and it is desirable that they should be repeated, especially on homogeneous solid wire of purest iron.

The author has the pleasure of acknowledging his indebtedness to Mr. L. U. Lingberg, Kohlsa, for the valuable specially selected research material, and to Mr. G. Tidholm, Garphyttan, for his kindness in drawing the wire.

University of Stockholm,
Stockholm, Sweden.

The Effect of Aluminium Chloride Upon a Naphthene Base Oil in the Formation of Gasoline, Unsaturated and Aromatic Hydrocarbons

BY GUSTAV EGLOFF AND ROBERT J. MOORE

In a previous communication¹ the effect of the chlorides of the metals and non-metals upon a paraffin base oil for the formation of gasoline was reported. The present paper deals with the effect of aluminium chloride in the formation of gasoline, unsaturated and aromatic hydrocarbons from a naphthene base oil.

Discussion of the Naphthenes

The naphthene, alicyclic or polymethylene hydrocarbons lie in physical and chemical properties between the aliphatic and aromatic hydrocarbons. They have the general empirical formula of C_nH_{2n} and are isomeric with the olefin series hydrocarbons. But, in contradistinction to the olefins they are saturated ring compounds. The physical constants of specific gravity and refractive index of naphthenes lie between the values of the aliphatic and aromatic compounds for

those individual naphthenes studied. In chemical behavior they resemble more nearly the paraffin than the aromatic hydrocarbons toward the common reagents such as sulphuric, nitric and halogen acids and the halogens themselves.

It has been known for a long time that in Russian and some American petroleum oils, fractions existed which, although having the same boiling points as the paraffin hydrocarbons, gave a higher specific gravity and the empirical formula of C_nH_{2n} . Although the empirical formula would indicate olefins, upon treatment with acids or halogens no addition compounds were formed. Furthermore, they did not act like aromatic hydrocarbons with the usual reagents. A number of these compounds have been isolated which neither reacted in the class of aliphatic or aromatic hydrocarbons and which gave the same physical and chemical properties as the synthesized polymethylenes of the hexahydrobenzene type or polycyclicmethylenes. Maberry² and others have isolated compounds of high boiling points and specific gravity giving upon hydrogen and carbon determination the formula C_nH_{2n} , but of whose constitution very little is known.

Naphthenes lack multiple bonds but have a closed carbon chain, one of the simplest being cyclohexane or hexamethylene, C_6H_{12} . Sabatier and Senderens³ readily converted aromatic hydrocarbons into naphthenes, as illustrated, by passing vapors of benzene and hydrogen over nickel: $C_6H_6 + 3H_2 \rightleftharpoons C_6H_{12}$.

Likewise with elimination of hydrogen from hexahydrobenzene or cyclohexane, benzene may be formed. Zelinsky⁴ performed this experiment with palladium at 300 deg. C. but found that at 100 deg. to 110 deg. C. the reverse reaction took place which indicates the ready reversibility of the reaction. The ready facility of the decomposition of a naphthene oil has been noted by Brooks and Humphrey⁵ and by others, a full bibliography of which is given in Engler-Höfer, "Das Erdöl." The ease with which the naphthenes may be decomposed and converted into hydrocarbons of widely different characteristics seemed to the authors to make them particularly adaptable to catalytic conversion work. It was with the endeavor of obtaining some light upon this point and to augment a general study of the aluminium chloride reaction on various type oils that the following work was undertaken:

Derivation of the Oil Used

The fractions used in the following experiments were derived from a naphthene base oil. The distillation analysis of the original oil from which the fractions were made analysed as given in Table 1. The distillation was carried on in a standard 200 c.c. Engler flask.

TABLE 1.

Temperature, Deg. C.	Specific gravity 0.878—15.5 deg. C. Per Cent by Volume	Specific Gravity 15.5 Deg. C.
175 to 200.....	1.8	.....
200 to 225.....	2.9	.....
225 to 250.....	4.5	0.842
250 to 275.....	6.3	0.844
275 to 300.....	6.2	0.818
300 to 325.....	3.5	0.850
325 to 350.....	4.9	0.854

Twenty-five gallons of this oil was distilled by steam, direct heating and vacuum. The first four fractions of the twenty-five gallons were made when 4 per cent for each cut came over. The fifth fraction was 8 per cent of the twenty-five gallons. Fractions three, four and

¹ Egloff and Moore, Met. and Chem. Eng., 15, 67, 1916.

² A paper will appear shortly by the authors giving the results of the action of aluminium chloride upon the individual aromatic hydrocarbons of the benzene series.

³ Maberry Proc. Amer. Acad. 37, 565, 1902. For full bibliography see Engler-Höfer, Das Erdöl, 316, 1913.

⁴ Sabatier and Senderens, Ann. Chim. Phys. 8, 4, 468, 1905.

⁵ Zelinsky, Berichte 44, 3121, 1911.

⁶ Brooks and Humphrey, Jour. Amer. Chem. Soc. 33, 393, 1916.

five were distilled in vacuum, so as to avoid possible decomposition of the oil. The highest fraction number six was redistilled with steam and direct heating at atmospheric pressure. With these fractions eliminated, the remaining 72 per cent of oil were enhanced in value as a lubricant of high flash and fire, low cold test and high viscosity at working temperatures; the latter property being usually recognized as an attribute of the naphthene hydrocarbons.

The flash point and fire test of the six fractions were taken. The flash point test was determined by means of the open cup method. Table 2 gives the data of the two sets of values for the flash point and fire test.

TABLE 2.

	Flash Point, Deg. F.	Fire Test, Deg. F.
Fraction 1.....	97	116
Fraction 2.....	138	155
Fraction 3.....	174	195
Fraction 4.....	200	230
Fraction 5.....	230	265
Fraction 6.....	280	305

The procedure adopted for the determination of unsaturated hydrocarbons was by use of c. p. sulphuric acid of specific gravity 1.84. The per cent of acid, the measuring cylinder and centrifuge used in the manipulation has already been given in detail.⁷

The method of nitrating the distillation cuts after the determination of olefins was by adding a nitration mixture consisting of one part 1.42 nitric acid to two parts of 1.84 sulphuric acid to the mixture of sulphonated and unsulphonated oil after cooling to zero deg. C. The mixture was then shaken thoroughly after the addition of the nitric-sulphuric acid mixture and cooled to zero for each addition. The unsulphonated and unnitrated residue oil was pipetted off, neutralized with a 10 per cent sodium hydroxide solution, washed with water and dried over fused calcium chloride. The number of c. c. absorbed read off on the measuring cylinder, and the results calculated to per cents in the cut.

The individual distillation, specific gravity and refractive index analysis of the six oils are given in Table 3. The specific gravity of the original six oils increased from 0.836 in oil one to 0.849 in oil six, while the refractive index ranged from 1.46150 to 1.46536. The temperature of the first drop of distillate appeared at the end of the condenser for the six oils from 145 deg. C. to 290 deg. C. The per cent by volume, specific gravity and refractive index values are compared between the six distillations of the oils as shown in Table 3.

The per cent of unsaturation, per cent nitrated and the per cent of remaining hydrocarbons unattacked by the acids of the distillation cuts of the original oils are given in Tables 4, 5 and 6. The maximum per cent of unsaturation was found in oil 3 of 8.3 per cent and a minimum was found in oil 3 of 1 per cent. From the data it is apparent that as the temperature of the distillation cuts increases, the percent of unsaturation decreases to a minimum in the distillation cut of 275 deg. to 300 deg. C. in oil 6.

The per cent of nitrated hydrocarbons in the distillation cuts of the six oils is given in Table 5. The per cent of nitratable hydrocarbons reached a maximum of 54.9 per cent in distillation cut 150 deg. to 175 deg. C. The per cent decreases steadily in the first distillation cut of each oil from 54.9 per cent in oil No. 1 to 13 per cent in oil No. 6. The high per cents of nitratable hydrocarbons in the original oils has called for

an investigation of the nitro derivatives of the hydrocarbons present in the oil.⁸

The per cent of hydrocarbons unattacked by sulphuric acid and nitric acid mixture from distillation cuts of the original oils is given in Table 6. It is to be noted that the per cent of unattacked hydrocarbons increases with increase of temperature of the distillation cuts. The minimum of unattacked hydrocarbons, 38.5, appears in oil No. 1 from the cut between 150 deg. to 175 deg. C., 54.9 per cent of this cut was nitrated, indicating a high per cent of aromatic hydrocarbons present.

In Table 7 the total per cent of sulphonated and nitrated hydrocarbons from the six oils is expressed. The distillation cut 150 deg. to 175 deg. C. in oil 1 gave a per cent of 61.5 for the total sulphonated and nitrated hydrocarbons. The per cent of sulphonated and nitrated hydrocarbons in the first distillation cut of each oil decreases from 61.5 in oil 1 to 14 per cent in oil 6. This indicates the increasing stability of the hydrocarbons toward the reagents sulphuric and nitric acids as the boiling points increase.

The specific gravity of the distillation cuts of the original six oils after sulphonation, nitration and washing in oil 1, 4 and 6 decreased, and increased in the other three oils. The experimental data in Table 8 shows that the reaction of aluminium chloride on the six oils used, derived from a naphthene base oil, first increases and then decreases the specific gravity of the distillation cuts after sulphonation and nitration.

The index of refraction shows a similar series of values in Tables 9 and 10.

The distillation cuts of the unattacked hydrocarbons were cooled to a temperature of from minus 6 to 10 deg. C., and showed no evidence of paraffins, either as the familiar bloom or by separating out.

The character of the foregoing results as based upon the distillation, specific gravity, refractive index, sulphonation and nitration, and cooling the unattacked hydrocarbons to minus 6 to 10 deg. C. indicates clearly the naphthenic character of the starting oils for the following study of the behavior of aluminium chloride in the formation of gasoline, unsaturated and aromatic hydrocarbons:

Summary as to the Character of Oils Used

1. Twenty-five gallons of a naphthene base oil were distilled by heat, steam and part in vacuum. The first four cuts being 4 per cent each, the fifth representing 8 per cent and the sixth cut 4 per cent of the starting twenty-five gallons.

2. The distillations were made in 25 deg. C. cuts, the per cent by volume, the specific gravity, refractive index, the per cent of unsaturation, the per cent of nitratable hydrocarbons in the cuts, and the per cent of unattacked hydrocarbons by sulphuric and nitric acid have been determined.

3. The specific gravities of the six oils range between 0.836 and 0.849. The refractive index values increased from 1.46150 to 1.46536. From the end of the condenser, the first drop in oil 1 was found to be 145 deg. C., which value increased to 290 deg. C. in oils 1 to 6. The distillation cuts gave gradual increase of the specific gravity and refractive index from oil 1 to 6.

4. The maximum of unsaturation was found in oil 3 of 8.3 per cent in cut 200 deg. to 225 deg. C., and a minimum of 1 per cent in oil 6.

⁸ An investigation of the nature and chemical constitution of the nitro-derivatives of the alicyclic hydrocarbons present in the various high boiling distillation cuts of the naphthene base oil is now being conducted in this laboratory.

⁷ Egloff and Twomey, Met. and Chem. Eng. 14, 247, 1916.

5. The maximum of nitrated hydrocarbons was found in oil 1 of 54.9 per cent in cut 150 deg. to 175 deg. C., with a minimum in oil 6 of 9.2 per cent in the residue.

6. Oil 6 gave a maximum of 87.7 per cent of un-nitrated hydrocarbons by sulphuric and nitric acid in the residue, with a minimum of 38.5 per cent in the cut 150 deg. to 175 deg. C in oil 1.

7. A total of 61.5 per cent of unsaturated and nitrated hydrocarbons in the distillation cut 150 deg. to 175 deg. C. in oil 1 was found. The minimum in oil 6 of 12.3 per cent was determined in the residue.

8. The specific gravity and refractive index of the distillation cuts after sulphonation, nitration and washing gave irregular results in the values of the two physical constants.

9. The distillation, specific gravity, refractive index, sulphonation, nitration and cooling to minus 6 to 10 deg. C., which latter test showed no signs of bloom or separation of paraffins, all of these tests indicate clearly the naphthenic characteristics of the starting six oils.

TABLE 3.

Distillation analysis of the original six oils.

Spec. grav.,	0.826	0.810	0.833	0.845	0.849	0.849
Ref. index,	1.46150	1.46170	1.46238	1.46308	1.46467	1.46536
First drop,	145 C.	174 C.	203 C.	230 C.	251 C.	290 C.
Fraction No.,	1	2	3	4	5	6
Temperature, deg. C.	Percent Volume	Percent Volume	Percent Volume	Percent Volume	Percent Volume	Percent Volume
150 to 175	1.5	0.8	.....	.....	.....	.....
175 to 200	48.5	19.0	.....	.....	.....	.....
200 to 225	32.8	35.7	.....	.....	.....	.....
225 to 250	.....	36.9	35.0	.....	.....	.....
250 to 275	.....	16.8	38.8	44.0	.....	.....
275 to 300	.....	.....	13.3	35.5	16.5	.....
300 to 325	.....	.....	.....	2.0	.....	.....
300 to 350	.....	.....	.....	.....	23.0	.....
Residue	19.0	16.3	9.1	13.1	17.3	56.0
Loss	1.5	1.1	1.5	0.8	1.2	2.5

Specific Gravity of the Distillation Cuts of Oils One to Six.

Sp. Gr.	Sp. Gr.	Sp. Gr.	Sp. Gr.	Sp. Gr.	Sp. Gr.	Sp. Gr.
150 to 175	0.831	.....	.....	.....	.....	.....
175 to 200	0.837	0.839	.....	.....	.....	.....
200 to 225	.....	0.841	0.841	.....	.....	.....
225 to 250	.....	0.844	0.844	.....	.....	.....
250 to 275	.....	0.845	0.844	.....	.....	.....
275 to 300	.....	.....	0.844	0.847	0.845	.....
300 to 350	.....	.....	.....	.....	0.846	.....
Residue	0.845	0.845	0.851	0.849	0.853	0.851

Refractive Index of the Distillation Cuts of Oils One to Six.

Ref. Ind.	Ref. Ind.	Ref. Ind.	Ref. Ind.	Ref. Ind.	Ref. Ind.	Ref. Ind.
150 to 175	1.46081	.....	.....	.....	.....	.....
175 to 200	1.46062	1.46199	.....	.....	.....	.....
200 to 225	1.46119	1.46198	.....	.....	.....	.....
225 to 250	.....	1.46160	1.46248	.....	.....	.....
250 to 275	.....	1.46297	1.46219	1.46418	.....	.....
275 to 300	.....	.....	1.46328	1.46409	1.46337	.....
300 to 350	.....	.....	.....	.....	1.46368	.....
Residue	1.46239	1.46249	1.46594	1.46536	1.46724	1.46605

TABLE 4.

The percent of unsaturation in the distillation cuts of the original six oils.

Fraction No.	1	2	3	4	5	6
Temperature, deg. C.	Percent Volume	Percent Volume	Percent Volume	Percent Volume	Percent Volume	Percent Volume
150 to 175	8.9	.....	.....	.....	.....	.....
175 to 200	5.3	7.0	.....	.....	.....	.....
200 to 225	1.3	8.3	.....	.....	.....	.....
225 to 250	.....	12	5.1	.....	.....	.....
250 to 275	.....	9.6	13.2	2.6	.....	.....
275 to 300	.....	.....	1.7	1.6	.....	.....
Residue	3.2	4.7	3.2	4.8	3.1	10

TABLE 5.

The percent of nitrated hydrocarbons in the distillation cuts of the original six oils.

Fraction No.	1	2	3	4	5	6
Temperature, deg. C.	Percent Volume	Percent Volume	Percent Volume	Percent Volume	Percent Volume	Percent Volume
150 to 175	54.9	17.6	.....	.....	.....	.....
175 to 200	16.9	.....	.....	.....	.....	.....
200 to 225	31.4	28.3	.....	.....	.....	.....
225 to 250	.....	21.3	15.9	.....	.....	.....
250 to 275	.....	14.9	15.9	14.8	.....	.....
275 to 300	.....	.....	14	20.8	.....	.....
Residue	20.9	11.1	22.4	13.2	11.1	13.0

TABLE 6.

The percent unattacked by sulphuric acid, and sulphuric and nitric acid mixture from the distillation cuts of the original oils.

Fraction No.	1	2	3	4	5	6
Temperature, deg. C.	Percent Volume	Percent Volume	Percent Volume	Percent Volume	Percent Volume	Percent Volume
150 to 175	38.5	.....	.....	.....	.....	.....
175 to 200	53.8	51.0	.....	.....	.....	.....
200 to 225	.....	64.3	23.1	.....	.....	.....
225 to 250	.....	.....	74.5	78.2	.....	.....
250 to 275	.....	.....	80.6	81.7	82.6	.....
275 to 300	.....	.....	.....	83.4	78.1	86.0
Residue	75.9	84.2	72.4	83.2	84.1	87.7

TABLE 7.

The total percent of unsaturated and nitrated hydrocarbons in the distillation cuts of the original six oils.

Fraction No.	1	2	3	4	5	6
Temperature, deg. C.	Percent Volume	Percent Volume	Percent Volume	Percent Volume	Percent Volume	Percent Volume
150 to 175	61.5	.....	.....	.....	.....	.....
175 to 200	46.2	49.0	.....	.....	.....	.....
200 to 225	.....	35.7	36.6	.....	.....	.....
225 to 250	.....	.....	24.5	21.3	.....	.....
250 to 275	.....	.....	19.4	18.3	17.4	.....
275 to 300	.....	.....	16.6	16.6	21.9	14.0
Residue	24.1	15.8	27.6	16.8	15.9	12.3

TABLE 8.

The specific gravity of the distillation cuts of the original six oils after sulphonation, nitration and washing.

Fraction No.	1	2	3	4	5	6
Temperature, deg. C.	Percent Volume	Percent Volume	Percent Volume	Percent Volume	Percent Volume	Percent Volume
150 to 175	0.818	.....	.....	.....	.....	.....
175 to 200	0.832	0.835	.....	.....	.....	.....
200 to 225	.....	0.845	.....	.....	.....	.....
225 to 250	.....	0.860	0.849	.....	.....	.....
250 to 275	.....	.....	.....	0.842	.....	.....
275 to 300	.....	.....	.....	.....	0.846	.....

TABLE 9.

The refractive index of the distillation cuts of the original six oils after sulphonation, nitration and washing.

Fraction No.	1	2	3	4	5	6
Temperature, deg. C.	Percent Volume	Percent Volume	Percent Volume	Percent Volume	Percent Volume	Percent Volume
150 to 175	1.45071	.....	.....	.....	.....	.....
175 to 200	1.45521	.....	.....	.....	.....	.....
200 to 225	1.45471	1.45361	.....	.....	.....	.....
225 to 250	.....	1.45581	1.45691	.....	.....	.....
250 to 275	.....	1.45531	1.45641	1.45711	.....	.....
275 to 300	.....	.....	1.45561	1.45571	1.45711	.....
Residue	1.45571	1.45561	1.45621	1.45841	.....	1.46060

Experimental Procedure

In each experiment a charge of 300 c.c. of the oil was taken and 10 per cent by weight of aluminium chloride added in a Kjeihdahl flask of 500 c.c. capacity to which was attached a 24-in. Liebig condenser. The temperature in the flask was maintained below 100 deg. C. for a period of twelve hours for each experiment. Whatever hydrocarbons boiling below 100 deg. C. were formed during this period of time condensed and were removed from the sphere of the reaction.

After twelve hours the residue in the flask was treated with a solution of 10 per cent of sodium hydroxide to clear the residue of the aluminium chloride present, filtered, washed and then dried with calcium chloride. The same procedure was carried out for the distillate, which came over during the twelve hours. The distillate and residue after drying were mixed and the volume, specific gravity and refractive index taken of the converted oil. In no case was there a heavy pitch-like residue left after the reaction such as is usually obtained from a paraffin base oil.

The method of analysis of each oil was by means of fractional distillation, specific gravity and refractive index, sulphonation and nitration. The distillations were made by means of a 300 c.c. round-bottom flask a Ginsky distilling head. The cuts were made by re-fractionating three times to 95 deg. C. (benzene cut); 95 deg. to 120 deg. C. (toluene cut); 120 deg. to 150 deg. C. (xylene cut) and single fractionating for every

25 deg. C. above 150 deg. C. in a standard 200 c.c. Engler flask until cracking of the oil took place from simple distillation at atmospheric pressure. This was noted as the temperature at which the mercury thread fell rapidly, although more heat was applied, which indicated lower boiling point hydrocarbon formation.

The specific gravity was determined by means of a Westphal balance having a plummet displacement of 1 c.c. at 15.5 deg. C. The refractive indices were determined by means of a Pulfrich refractometer at 20 deg. C.

Experimental Data

The experimental data are brought out in the following order by means of tables and graphs.

Table 10. The distillation analysis, specific gravity and refractive index of oils 1 to 6 compared with the recovered oil after reaction with aluminium chloride.

Table 11 and Fig. 1. The effect of aluminium chloride on the per cent of recovered oil, the specific gravity and refractive index of the recovered oil.

Table 12. The comparison of the effect of aluminium chloride on the distillation analysis of the six fractions.

Table 13. The effect of aluminium chloride on the specific gravity of the distillation cuts of the six fractions of a naphthene base oil.

Table 14. The effect of aluminium chloride on the refractive index of the distillation cuts of the six fractions of a naphthene base oil.

Table 15 and Fig. 2. The effect of aluminium chloride on the formation of gasoline from the six fractions on the basis of recovered oil.

Table 16 and Fig. 3. The effect of aluminium chloride on the formation of gasoline and specific gravity of the gasoline from the six fractions on basis of the oil used for production.

Table 17 and Fig. 4. The formation of benzene, toluene, and xylene from the action of aluminium chloride on the six oils on the basis of per cent in the recovered oil.

Table 18 and Fig. 5. The formation of benzene, toluene and xylene from the action of aluminium chloride on the six oils on basis of oil used for production.

Table 19. The specific gravity of the benzene, toluene and xylene cuts resulting from the aluminium chloride conversion of the six oils.

Table 20. The per cent of unsaturation in the distillation cuts after conversion of the six oils.

Table 21. The per cent nitrated in the distillation cuts after conversion of the six oils.

Table 22. The comparison of the per cent of unsaturation, per cent nitrated, and per cent unattacked by acids of the distillation cuts from the converted oils.

Table 23. The refractive index of the distillation cuts of the converted oil after sulphonation, nitration and washing.

Table 24. The specific gravity of the distillation cuts of the converted oil after sulphonation, nitration and washing.

Temp. deg. C.	Original		After		Original Frac'tion Ref. Ind.	After Treatm't Ref. Ind.
	Fraction Pct. Vol.	Sp. Gr.	Fraction Pct. Vol.	Sp. Gr.		
To 95	.....	4.5	.....	4.77	.....	1.42291
95 to 120	.....	5.2	.....	5.74	.....	1.43552
120 to 150	.....	11.4	.....	12.1	.....	1.45982
150 to 175	 0.8	1.5	.....	0.831	.....	1.45621
175 to 200	 49.0	2.9	.....	0.823	1.46199	1.45671
200 to 225	 32.8	25.9	0.841	0.847	1.46119	1.45741
225 to 250	 18.3	13.5	.....	0.837	.....	1.45821
250 to 275	.....	2.9	.....	0.849	.....	1.45881
275 to 300	.....	1.8	.....	0.870	.....	1.45881
300 to 325	.....	0.4	.....	0.879	.....	1.47598
325 to 350	.....	0.1	.....	0.879	.....	1.47598
350 to 385	.....	0.1	.....	0.879	.....	1.47598
Residue	 16.3	9.1	0.871	0.820	1.46594	1.45204
Loss	 1.1	0.7	.....	.....	.....	.....

Temp. deg. C.	Original		After		Original Frac'tion Ref. Ind.	After Treatm't Ref. Ind.
	Fraction Pct. Vol.	Sp. Gr.	Fraction Pct. Vol.	Sp. Gr.		
To 95	.....	7.5	.....	7.77	.....	1.39139
95 to 120	.....	9.1	.....	9.76	.....	1.41118
120 to 150	.....	14.7	.....	15.66	.....	1.43784
150 to 175	.....	1.0	.....	0.824	.....	1.45841
175 to 200	.....	8.6	.....	0.828	.....	1.45931
200 to 225	 35.7	17.7	0.841	0.831	1.46198	1.45471
225 to 250	 36.9	17.7	0.844	0.832	1.46166	1.45481
250 to 275	 18.3	8.8	0.845	0.837	1.46297	1.45411
275 to 300	.....	1.5	.....	0.844	.....	1.46436
300 to 325	.....	0.1	.....	0.844	.....	1.47176
325 to 350	.....	0.2	.....	0.844	.....	1.47224
350 to 385	.....	0.7	.....	0.844	.....	1.47450
Residue	 9.1	9.1	0.871	0.820	1.46594	1.45204
Loss	 1.5	0.7	.....	.....	.....	.....

Temp. deg. C.	Original		After		Original Frac'tion Ref. Ind.	After Treatm't Ref. Ind.
	Fraction Pct. Vol.	Sp. Gr.	Fraction Pct. Vol.	Sp. Gr.		
To 95	.....	12.9	.....	0.708	.....	1.38884
95 to 120	.....	12.3	.....	0.760	.....	1.41718
120 to 150	.....	12.9	.....	0.785	.....	1.43178
150 to 175	.....	2.0	.....	0.804	.....	1.44588
175 to 200	.....	6.2	.....	0.812	.....	1.44731
200 to 225	.....	7.7	.....	0.820	.....	1.45021
225 to 250	 35.0	13.3	0.844	0.826	1.46248	1.45111
250 to 275	 38.8	18.7	0.844	0.826	1.46219	1.45111
275 to 300	 12.3	8.9	0.844	0.828	1.46328	1.45421
300 to 325	.....	0.6	.....	0.844	.....	1.45931
325 to 350	.....	0.1	.....	0.844	.....	1.45641
350 to 385	.....	0.1	.....	0.844	.....	1.45656
Residue	 13.1	3.6	0.849	0.820	1.46594	1.46980
Loss	 0.8	1.5	.....	.....	.....	.....

Temp. deg. C.	Original		After		Original Frac'tion Ref. Ind.	After Treatm't Ref. Ind.
	Fraction Pct. Vol.	Sp. Gr.	Fraction Pct. Vol.	Sp. Gr.		
To 95	.....	17.3	.....	0.697	.....	1.38301
95 to 120	.....	13.7	.....	0.751	.....	1.41065
120 to 150	.....	16.3	.....	0.782	.....	1.42971
150 to 175	.....	1.0	.....	0.799	.....	1.44700
175 to 200	.....	1.3	.....	0.814	.....	1.44559
200 to 225	.....	4.0	.....	0.816	.....	1.44731
225 to 250	.....	5.4	.....	0.818	.....	1.44881
250 to 275	 44.0	9.4	0.847	0.821	1.46418	1.44891
275 to 300	 35.5	9.0	0.847	0.822	1.46409	1.44891
300 to 325	 2.0	0.7	.....	0.847	.....	1.44951
325 to 350	.....	0.5	.....	0.847	.....	1.44981
350 to 385	.....	1.3	.....	0.847	.....	1.44981
Residue	 17.3	29.0	0.853	0.834	1.46724	1.45071
Loss	 1.2	1.5	.....	.....	.....	.....

Temp. deg. C.	Original		After		Original Frac'tion Ref. Ind.	After Treatm't Ref. Ind.
	Fraction Pct. Vol.	Sp. Gr.	Fraction Pct. Vol.	Sp. Gr.		
To 95	.....	17.5	.....	0.683	.....	1.37819
95 to 120	.....	12.0	.....	0.742	.....	1.40714
120 to 150	.....	15.0	.....	0.769	.....	1.42170
150 to 175	.....	0.5	.....	0.785	.....	1.43328
175 to 200	.....	0.9	.....	0.800	.....	1.43855
200 to 225	.....	2.0	.....	0.810	.....	1.44156
225 to 250	.....	4.2	.....	0.810	.....	1.44498
250 to 275	.....	7.1	.....	0.845	1.46337	1.44761
275 to 300	 18.5	.....	0.845	0.846	1.46368	1.45121
300 to 350	 23.0	.....	0.846	0.846	1.46605	1.45601
Residue	 56.0	.....	0.851	0.851	1.46605	1.45601
Loss	 2.5	.....	.....	.....	.....	.....

TABLE No. 11.

The effect of aluminium chloride on the per cent of recovered oil, the specific gravity and refractive index of the recovered oil.

Oil Number	1	2	3	4	5	6
Percent Recovered	79.3	78.3	77.0	68.0	60.0	72.0
Specific Gravity	0.832	0.835	0.811	0.797	0.773	0.774
Refractive Index	1.45861	1.45921	1.44861	1.43855	1.42471	1.42605

TABLE No. 12

The comparison of the effect of aluminium chloride on the distillation analysis of the six oils.

Oil Number	1	2	3	4	5	6
Temperature deg. C.						
To 95		4.6	.....	.....	.....	.....
95 to 120		20.7	.....	.....	.....	.....
120 to 150		13.4	.....	.....	.....	.....
150 to 175		33.0	.....	.....	.....	.....
175 to 200		10.2	.....	.....	.....	.....
200 to 225		4.8	.....	.....	.....	.....
225 to 250						
250 to 275						
275 to 300						
300 to 325						
325 to 350						
350 to 385						
Residue		4.7	.....	.....	.....	.....
Loss		1.1	.....	.....	.....	.....

TABLE No. 10

The distillation analysis, specific gravity and refractive index of oils one to six compared with recovered oil after reaction with aluminium chloride.

Temp. deg. C.	Original		After		Original Frac'tion Ref. Ind.	After Treatm't Ref. Ind.
	Fraction Pct. Vol.	Sp. Gr.	Fraction Pct. Vol.	Sp. Gr.		
To 95	.....	4.8	.....	0.754	.....	1.41516
95 to 120	.....	7.5	.....	0.784	.....	1.43078
120 to 150	 1.5	20.7	.....	0.812	.....	1.44811
150 to 175	 48.5	13.4	0.831	0.829	1.46081	1.45641
175 to 200	 29.5	33.0	0.837	0.836	1.46062	1.45961
200 to 225	.....	10.2	.....	0.845	.....	1.46515
225 to 250	.....	4.8	.....	0.855	.....	1.47048
250 to 275	.....	4.7	0.845	0.846	1.46239	1.451236
Residue	 19.0	4.7	0.845	0.846	1.46239	1.451236
Loss	 1.5	1.1	.....	.....	.....	.....

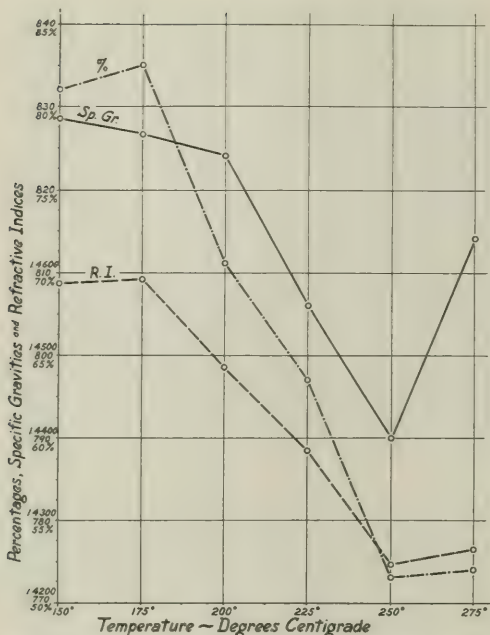


FIG. 1—THE EFFECT OF ALUMINIUM CHLORIDE ON THE PER CENT OF RECOVERED OIL, THE SPECIFIC GRAVITY AND REFRACTIVE INDEX OF THE RECOVERED OIL

TABLE No. 13.

The effect of aluminum chloride on the specific gravity of the distillation cuts of six fractions of a naphthene Base Oil

Fraction No.	1	2	3	4	5	6
Temperature deg. C.	Sp. Gr.	Sp. Gr.	Sp. Gr.	Sp. Gr.	Sp. Gr.	Sp. Gr.
To 95	0.754	0.771	0.713	0.708	0.697	0.683
95 to 120	0.784	0.794	0.761	0.760	0.751	0.742
120 to 150	0.812	0.814	0.796	0.785	0.782	0.769
150 to 175	0.829	0.831	0.824	0.804	0.799	0.785
175 to 200	0.836	0.833	0.828	0.812	0.814	0.800
200 to 225	0.845	0.837	0.831	0.820	0.816	0.810
225 to 250	0.855	0.839	0.833	0.826	0.818	...
250 to 275	...	0.849	0.837	0.826	0.821	...
275 to 300	...	0.870	0.844	0.828	0.822	...
300 to 325	...	0.879	...	...	...	...
Residue	0.910	0.950	0.920	...	0.834	...

TABLE No. 14.

The effect of aluminum chloride on the refractive index of the distillation cuts of six fractions of a naphthene base oil.

Fraction No.	1	2	3	4	5	6
Temperature deg. C.	Ref. Ind.	Ref. Ind.	Ref. Ind.	Ref. Ind.	Ref. Ind.	Ref. Ind.
To 95	1.41516	1.42291	1.39139	1.38884	1.38301	1.37819
95 to 120	1.43078	1.43552	1.41708	1.41718	1.41065	1.40714
120 to 150	1.44811	1.44589	1.43784	1.43178	1.42977	1.42170
150 to 175	1.45641	1.45621	1.45341	1.44388	1.44700	1.43328
175 to 200	1.45961	1.45671	1.45391	1.44710	1.44559	1.43885
200 to 225	1.46515	1.45741	1.45471	1.45021	1.44731	1.44155
225 to 250	1.47048	1.45821	1.45481	1.45111	1.44881	1.44498
250 to 275	...	1.46506	1.45811	1.45111	1.44891	1.44761
275 to 300	...	1.47588	1.46436	1.45421	1.44891	1.45121
300 to 325	...	1.47598	1.47176	1.45531	1.44951	...
325 to 350	...	1.48315	1.47224	1.45841	1.44981	...
350 to 375	...	1.48956	1.47450	1.45991	...	...
Residue	1.51236	1.54520	1.52031	1.46980	1.45071	1.45561

TABLE No. 15.

The effect of aluminum chloride on the formation of gasoline from the six fractions on the basis of recovered oil.

Fraction No.	1	2	3	4	5	6
Percent Gasoline	32.8	23.5	30.9	38.3	47.3	44.5

TABLE No. 16.

The effect of aluminum chloride on the formation of gasoline and specific gravity of the gasoline from the six fractions on basis of oil used for production.

Fraction No.	1	2	3	4	5	6
Percent Gasoline	26.0	18.4	23.8	26.0	28.4	32.1
Specific Gravity	0.781	0.801	0.765	0.748	0.741	0.726

TABLE No. 17.

The formation of benzene, toluene and xylene from the action of aluminum chloride on the six oils, on the basis of percent in the recovered oil.

Oil No.	1	2	3	4	5	6
Percent—						
Benzene	0.98	1.43	...	...	...	...
Toluene	2.96	2.38	2.02	2.85	2.05	1.03
Xylene	9.80	6.78	4.68	2.96	3.26	1.23

TABLE No. 18.

The formation of benzene, toluene and xylene from the action of aluminum chloride on the six oils on basis of oil used for production.

Oil No.	1	2	3	4	5	6
Percent—						
Benzene	0.78	1.11	...	...	...	...
Toluene	2.35	1.87	1.56	1.94	1.23	0.74
Xylene	7.80	5.31	3.60	2.01	1.36	0.88

TABLE 19.

The specific gravity of the benzene, toluene and xylene cuts resulting from the aluminum chloride conversion of the six oils.

Oil No.	1	2	3	4	5	6
Specific Gravity	0.754	0.771	0.713	0.708	0.697	0.683
Benzene cut	0.754	0.771	0.713	0.708	0.697	0.683
Toluene cut	0.784	0.794	0.761	0.760	0.751	0.742
Xylene cut	0.812	0.814	0.796	0.785	0.782	0.769

TABLE 20.

The per cent unsaturated hydrocarbons in the distillation cuts after conversion of the six oils.

Oil No.	1	2	3	4	5	6
Temperature, Deg. C.	Per Cent by Volume	Per Cent by Volume	Per Cent by Volume	Per Cent by Volume	Per Cent by Volume	Per Cent by Volume
to 95	Trace	0.0	0.0	0.0	3.3	0.0
95 to 120	0.0	0.0	0.0	0.0	Trace	Trace
120 to 150	0.0	Trace	0.0	Trace	Trace	Trace
150 to 175	3.3	6.5	8.6	5.1	...	...
175 to 200	1.7	1.8	3.2	2.5	9.5	...
200 to 225	3.1	2.0	3.1	3.7	10.0	...
225 to 250	3.5	1.7	3.1	1.6	3.3	...
250 to 275	...	3.0	3.3	4.1	3.4	...
275 to 300	...	6.0	6.7	5.0	4.3	...
Residue	...	Sludge	Sludge	20.1	3.3	...

TABLE 21.

The per cent nitrated in the distillation cuts after conversion of the six oils.

Oil No.	1	2	3	4	5	6
Temperature, Deg. C.	Per Cent by Volume	Per Cent by Volume	Per Cent by Volume	Per Cent by Volume	Per Cent by Volume	Per Cent by Volume
to 95	0.0	0.0	0.0	0.0	5.0	0.0
95 to 120	20.0	31.0	13.2	20.3	11.4	8.3
120 to 150	43.3	43.0	30.0	26.7	13.0	13.3
150 to 175	40.0	34.8	22.8	25.1	...	...
175 to 200	43.6	33.0	25.8	25.3	20.1	...
200 to 225	36.9	24.2	18.8	20.2	10.0	...
225 to 250	31.3	15.0	10.0	10.2	9.3	...
250 to 275	...	15.7	11.5	3.3	3.5	...
275 to 300	...	22.0	10.0	3.3	5.0	...
Residue	...	...	...	40.2	5.9	...

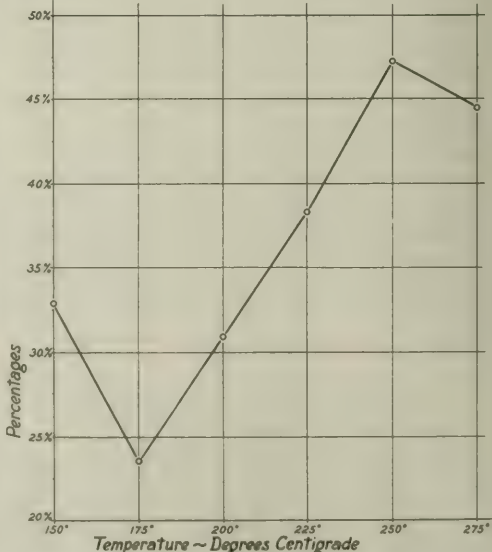


FIG. 2—THE EFFECT OF ALUMINIUM CHLORIDE ON THE FORMATION OF GASOLINE FROM THE SIX FRACTIONS ON THE BASIS OF RECOVERED OIL

TABLE 22.

The comparison of the per cent of unsaturated, per cent nitrated and per cent unattacked by acids of the distillation cuts from the converted oils.

Oil 1.					
Temperature, Deg. C.	Orig. Fract.	Per Cent Unsaturated After $AlCl_3$ Treatment	Orig. Fract.	Per Cent Nitrated After $AlCl_3$ Treatment	Per Cent Unattacked After $AlCl_3$ Treatment
to 95.....	0.0	0.0	...	20.0	80.0
95 to 120.....	0.0	0.0	...	43.3	56.7
120 to 150.....	0.0	0.0	...	40.0	60.0
150 to 175.....	5.3	1.7	40.9	45.6	54.4
175 to 200.....	...	3.1	...	36.9	63.1
200 to 225.....	...	3.5	...	31.3	68.7
225 to 250.....	...	...	...	...	...
250 to 275.....	...	...	...	...	...
275 to 300.....	...	...	...	...	...
Residue.....	3.2	...	20.9	...	79.1
Oil 2.					
to 95.....	Trace	0.0	...	20.0	80.0
95 to 120.....	0.0	0.0	...	31.0	69.0
120 to 150.....	0.0	0.0	...	43.0	57.0
150 to 175.....	6.5	1.8	...	34.8	65.2
175 to 200.....	7.0	1.3	42.6	33.9	66.1
200 to 225.....	4.3	2.0	31.4	24.2	75.8
225 to 250.....	...	1.7	...	15.0	85.0
250 to 275.....	...	3.0	...	15.7	84.3
275 to 300.....	...	6.0	...	22.0	78.0
Residue.....	4.7	Sludge	11.1	...	88.9
Oil 3.					
to 95.....	0.0	0.0	...	0.0	100.0
95 to 120.....	0.0	0.0	...	13.2	86.8
120 to 150.....	Trace	0.0	...	30.0	70.0
150 to 175.....	8.6	0.0	...	22.8	77.2
175 to 200.....	3.2	0.0	...	25.8	74.2
200 to 225.....	8.3	3.1	28.3	18.8	81.2
225 to 250.....	4.2	3.1	21.3	10.9	89.1
250 to 275.....	5.5	3.3	13.9	11.5	88.5
275 to 300.....	...	6.7	...	10.0	90.0
Residue.....	5.2	Sludge	22.4	...	77.6
Oil 4.					
to 95.....	0.0	0.0	...	0.0	100.0
95 to 120.....	0.0	0.0	...	20.3	79.7
120 to 150.....	0.0	0.0	...	26.7	73.3
150 to 175.....	5.1	0.0	...	25.1	74.9
175 to 200.....	2.6	0.0	...	25.3	74.7
200 to 225.....	3.7	0.0	...	20.2	79.8
225 to 250.....	5.4	1.6	15.9	10.2	89.8
250 to 275.....	3.3	4.1	15.0	8.7	91.3
275 to 300.....	1.7	5.0	14.9	3.3	96.7
Residue.....	3.6	20.4	13.2	40.2	59.8

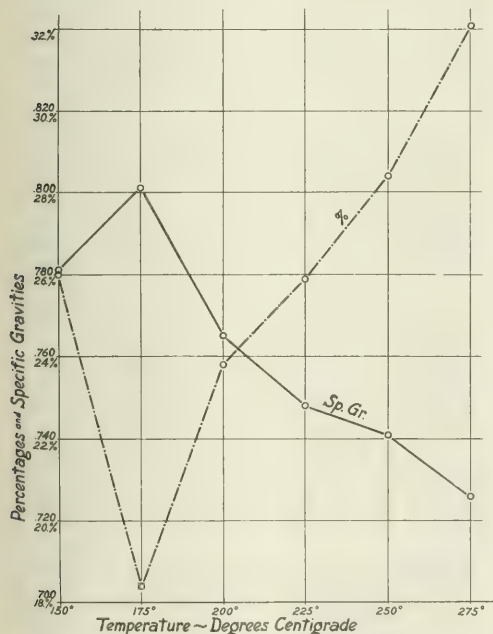


FIG. 3—THE EFFECT OF ALUMINIUM CHLORIDE ON THE FORMATION OF GASOLINE AND SPECIFIC GRAVITY OF THE GASOLINE FROM THE SIX FRACTIONS ON BASIS OF OIL USED FOR PRODUCTION

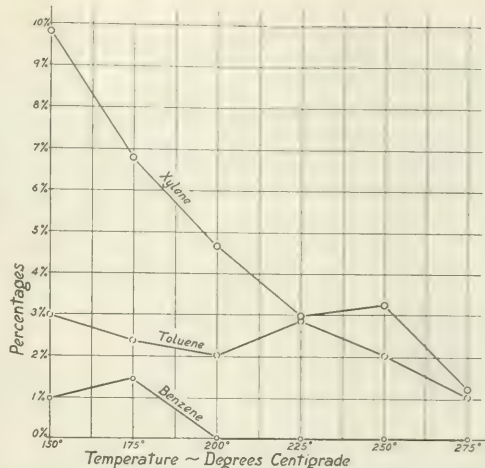


FIG. 4—THE FORMATION OF BENZENE, TOLUENE AND XYLENE FROM THE ACTION OF ALUMINIUM CHLORIDE ON THE SIX FRACTIONS ON THE BASIS OF PER CENT IN THE RECOVERED OIL

Oil 5.					
Temperature, Deg. C.	Orig. Fract.	Per Cent Olefins After $AlCl_3$ Treatment	Orig. Fract.	Per Cent Nitrated After $AlCl_3$ Treatment	Unnitrated and Unsulphonated After $AlCl_3$ Treatment
to 95.....	...	3.3	...	5.0	91.7
95 to 120.....	...	0.0	...	11.4	88.6
120 to 150.....	Trace	...	...	13.0	87.0
150 to 175.....	...	...	...	...	...
175 to 200.....	...	9.5	...	20.1	79.9
200 to 225.....	...	10.0	...	10.0	90.0
225 to 250.....	...	3.3	...	9.3	90.7
250 to 275.....	2.6	3.4	14.8	3.0	96.6
275 to 300.....	1.6	4.3	20.3	5.0	94.7
Residue.....	4.8	3.3	11.1	5.9	84.1
Oil 6.					
to 95.....	...	0.0	...	0.0	100.0
95 to 120.....	Trace	...	...	8.3	91.7
120 to 150.....	Trace	...	...	13.3	86.7
150 to 175.....	...	...	...	...	...
175 to 200.....	...	...	...	...	...
200 to 225.....	...	...	...	...	...
225 to 250.....	...	...	...	...	...
250 to 275.....	...	...	...	...	...
275 to 300.....	1.0	...	13.0	...	86.0
Residue.....	3.1	...	9.2	...	90.8

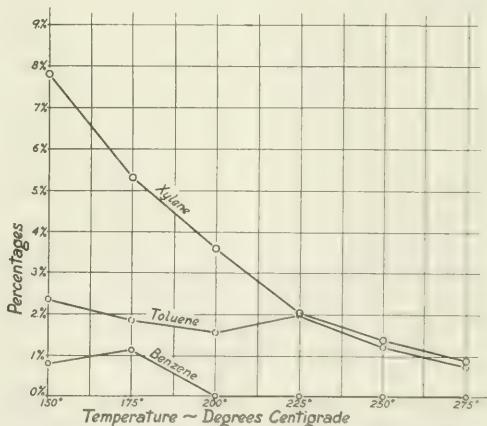


FIG. 5—THE PER CENT OF BENZENE, TOLUENE AND XYLENE FROM THE ACTION OF ALUMINIUM CHLORIDE ON THE SIX FRACTIONS ON BASIS OF OIL USED FOR PRODUCTION

TABLE 23.

The refractive index of the distillation cuts of the converted oil after sulphonation, nitration and washing.

Oil No.	2	3	4	5	6
Temperature, Deg. C.	Refractive Index				
95 to 120.....	1.42291	1.39139	1.38884	1.39128	1.37819
120 to 150.....	1.42122	1.41015	1.40955	1.40664	1.41766
150 to 175.....	1.43219	1.42352	1.41898	1.42019	1.41766
175 to 200.....	1.44247	.....	.....	.....	.....
200 to 225.....	1.45011	1.44468	1.43633	.....	.....
225 to 250.....	1.45131	1.44751	1.44116	.....	.....
250 to 275.....	1.45531	1.45271	1.44700	1.44800	.....
275 to 300.....	1.45891	.....	1.44801	1.44791	.....
Residue.....	.....	.....	1.44911	1.44801	.....
				1.45231	.....

TABLE 24.

The specific gravity of the distillation cuts of the converted oil after sulphonation, nitration and washing.

Oil No.	2	3	4	5	6
Temperature, Deg. C.	Specific Gravity				
175 to 200.....	0.846	.....	.....	.....	.....
200 to 225.....		0.837	.....	.....	.....
225 to 250.....			0.833	.....	.....
250 to 275.....				0.830	.....
275 to 300.....					0.826

Discussion of Experimental Data

A. THE DISTILLATION ANALYSIS, SPECIFIC GRAVITY AND REFRACTIVE INDEX OF THE SIX OILS COMPARED WITH THE RECOVERED OIL AFTER REACTION WITH ALUMINIUM CHLORIDE

In each oil treated with aluminium chloride the reaction tended toward the formation of hydrocarbons of much lower boiling points, lower specific gravity and lower refractive index than in the original.

In oil 1, the per cent boiling below 150 deg. C. of the original was 1.5, while the per cent boiling below

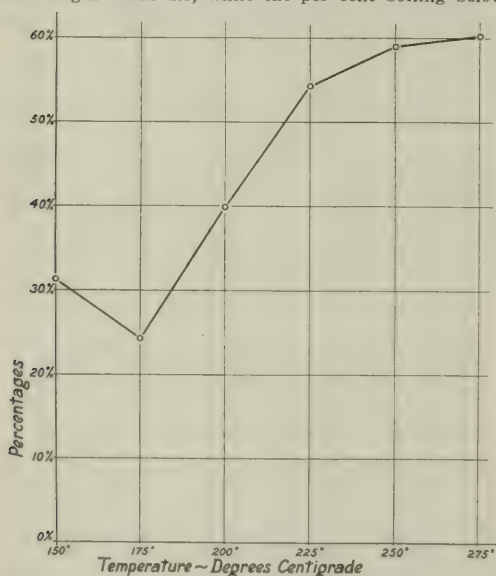


FIG. 6—THE PER CENT BOILING BELOW THE LOWEST BOILING CONSTITUENT OF THE ORIGINAL FRACTION AFTER CONVERSION

this temperature after the reaction was 32.8. Between the temperatures of 150 deg. C. and 175 deg. C. 48.5 per cent boiled between these temperature limits in the original oil, while treatment of the fraction with aluminium chloride converted 35.1 per cent to higher and lower boiling point constituents. The reaction

tended mainly in the direction of lower boiling point hydrocarbons.

Oil 2 originally yielded 0.8 per cent below 175 deg. C., while after treatment 25.0 per cent distilled over below this temperature. The specific gravity and refractive index of the distillation cuts after conversion of the fraction were found to be lower than the corresponding cuts of the original.

In oil 3 the 35.7 per cent boiling below 225 deg. C. was converted with the other fractions boiling above, to 57.4 per cent, a difference of 21.7 per cent. Although the starting oil gave a percentage of 72.6 boiling between the limits of 200 deg. and 250 deg. C., after reacting with aluminium chloride the per cent between these limits changed to 35.8 per cent, with a change of specific gravity and refractive index lower than the original oil.

Oil 4, after conversion, gave 54.3 per cent of hydrocarbons with boiling points below the lowest boiling constituent of the starting fraction. This amount of conversion came mainly from the cuts boiling between 225 deg. and 275 deg. C., of which 73.8 per cent of the fraction of the naphthene oil boiled between these temperature limits. Only 12.4 per cent of the converted oil boiled above the temperature of 275 deg. C., which indicates that this particular fraction under the conditions of the experiment went mainly to hydrocarbons of much lower volatility than the starting oil.

Oil 5, after conversion, gave 59 per cent below the temperature of 250 deg. C., whereas the original oil gave zero per cent. A change of 35 per cent occurred in the cut boiling between 250 deg. and 275 deg. C. after the aluminium chloride treatment. The cut between 275 deg. and 300 deg. C. gave a difference of 26.5 per cent after treatment. The differences in the per cent of the two cuts show conversion mainly toward the lower boiling point hydrocarbons and a very small per cent toward higher boiling point substances. The differences between the specific gravity and refractive index values are more marked in the conversion of oil 5 than in any of the previously described oils.

Oil 6 upon treatment with aluminium chloride gave a percentage of 60.2, boiling below the temperature of the lowest boiling point constituent of the original oil. The hydrocarbons are of a much lower volatility than any preceding converted oil.

The tabulation in Table 25 of the per cent of the mixture of paraffin, unsaturated, benzene and naphthene series hydrocarbons boiling below the lowest boil-

TABLE 25.

Temperatures of lowest boiling constituent in the original fraction in degrees Centigrade.....	150	175	200	225	250	275
Oil No.	1	2	3	4	5	6
Per cent boiling below the lowest boiling point constituent of the original oil after conversion.....	31.3	24.3	39.9	54.3	59.0	60.2

The data are expressed graphically in Fig. 6.

ing point constituent of the original oil, will give a clear idea as to the conversion due to the action of aluminium chloride upon the six fractions of a naphthene base oil.

B. THE EFFECT OF ALUMINIUM CHLORIDE ON THE PER CENT OF RECOVERED OIL, SPECIFIC GRAVITY, AND REFRACTIVE INDEX OF THE RECOVERED OIL

As the oils increased from one to five, the per cent of recovered oil decreased to a minimum of 60 per cent and then increased in fraction 6 to 72 per cent. The specific gravity of the recovered oil showed a maximum in fraction two of 0.835 and a minimum in fraction five

of 0.773. Fraction six increased slightly over fraction five giving a value of 0.774 for its specific gravity. The refractive index values paralleled the values for specific gravity indicating the additive property of the refractive index constant for hydrocarbons.¹⁰ In Fig. 1 the data are expressed graphically.

C. THE EFFECT OF ALUMINIUM CHLORIDE ON THE PER CENT BY VOLUME OF THE CUTS OF THE SIX FRACTIONS OF THE NAPHTHENE BASE OIL

In the benzene cut to 95 deg. C. the per cent of the low boiling hydrocarbons increased from 4.6 per cent to 17.5 in going from oils one to six. The toluene cut 95 deg. to 120 deg. C. showed two minima, 5.2 per cent resulting from oil 2 and 12 per cent from oil six. The xylene cut 120 deg. to 150 deg. C., shows an alternate maximum and minimum. In the cut from 150 deg. to 175 deg. C. a very small percentage is to be noted with the exception of oil one, which would indicate a very small, if any, formation of the trimethyl benzenes. In the other distillation cuts no regularity is apparent in the percentages of the cuts in the recovered oil.

D. THE EFFECT OF ALUMINIUM CHLORIDE ON THE SPECIFIC GRAVITY OF THE DISTILLATION CUTS OF THE SIX FRACTIONS OF A NAPHTHENE BASE OIL

In the cut to 95 deg. C. the specific gravity is shown as a maximum of 0.771 in oil two. The cut shows two minima of 0.754 in oil one and of 0.683 in oil six.

In each cut up to 175 deg. C. the maximum specific gravity was found to be in fraction two. Between 175 deg. and 200 deg. C. the maximum is attained in fraction one and the specific gravity decreases in this cut from fraction one to six. In each converted fraction the specific gravity of the cuts increases as the distillation cuts increase in temperature with one exception, this is that the specific gravity of two cuts is the same in oil four. The distillation cut from 225 deg. to 250 deg. C. and the cut from 250 deg. to 275 deg. C. in oil four gave each a specific gravity of 0.826.

E. THE EFFECT OF ALUMINIUM CHLORIDE ON THE REFRACTIVE INDEX OF THE DISTILLATION CUTS OF THE SIX FRACTIONS OF A NAPHTHENE BASE OIL

The refractive index of oils, such as those under investigation is not only a simple physical constant to determine, requiring only a drop of liquid, but in addition furnishes a valuable criterion in judging the nature of the type of hydrocarbons present in the oils, in conjunction with the specific gravity, sulphonation and nitration of the various distillation cuts made.

Although the index of refraction is an additive property for each type of oil, similar in respects to the specific gravity, yet the refractive indices for the paraffin, aromatic and naphthene series hydrocarbons are widely different in value. This may be seen in table 26,

TABLE 26.

	Boiling Point Range	Index of Refraction Average
Paraffins	68 deg to 174 deg C	1.403
Naphthenes	80 deg to 172 deg C	1.423
Aromatics	80 deg to 167 deg C	1.501

based upon the average refractive indices of the three groups of hydrocarbons between the temperatures selected as the boiling points of the paraffin, aromatic and naphthene present in similar boiling point temperatures of the converted distillation cuts.

A wide divergence between the values of paraffins and aromatics is shown by table 26. An oil containing a mixture of the three hydrocarbons would show an

index of refraction value somewhere between the values of the paraffins and aromatics. For example a mixture of paraffins, naphthenes and aromatics would give an index value depending upon the percentage of each type present in the oil. Now, if the mixture is nitrated the index of refraction value of the remainder of the liquid should show a value more clearly illustrative of its paraffin-naphthenic nature. The five examples taken from the data on the converted oils illustrates this. Table 27 shows this phenomenon:

The index value in each case is materially lowered after removal of the aromatics. There remains an oil

TABLE 27.

The index of refraction of the distillation cuts before and after nitration.

Oil Number	Distillation cut Deg. C.	Index of Refraction Before Nitration	Index of Refraction After Nitration
1	175 to 200	1.44671	1.44480
2	200 to 225	1.45471	1.44781
3	225 to 250	1.45111	1.44700
4	250 to 275	1.44891	1.44791
5	275 to 300	1.45121	1.44991

whose boiling point range and index of refraction are known and which reacts chemically similar to either paraffins or naphthenes. The index of the oil corresponds closely to the values of naphthene oils at those temperatures as given in Engler-Höfer's "Das Erdöl." The latter reference gives for naphthenes boiling between 175 deg. to 201 deg. C., the value 1.44009. Our value for the fraction 175 deg. to 200 deg. C. is 1.44463, a fairly close approximation to the value of pure naphthenes. On these residues no bloom or paraffin separation was shown on cooling below zero deg. C., and this, in conjunction with the other physical and chemical tests, was taken as evidence of their naphthene content.

In the same manner the indices in table 23 taken after nitration of the converted oils are all uniformly lower than the indices before nitration as shown in table 10. It will be noticed, however, in table 23 that there is a general tendency toward lower indices of refraction values with increase of the boiling point fractions of the oils from 175 deg. to 300 deg. C. This is significant since the specific gravity values of the same cuts as shown in table 24 show a uniform decrease with increase of boiling point of the fractions as we go from oil number 2 to oil 6. In other words fraction from 275 deg. to 300 deg. C. of oil 6 shows a lower specific gravity than fraction 175 deg. to 200 deg. C. of oil 2.

This apparent contradiction to usual experience with oils seems at first difficult of explanation but some light is thrown upon this phenomenon if the amount of conversion of each starting oil is taken into consideration. It must be remembered that the six starting oils are distillation cuts from the same crude naphthene base oil and each oil from number one to six is a higher boiling-point fraction. Of the six oils, the highest boiling ones were number 5 and 6 which gave the highest percentage of conversion to lower boiling-point hydrocarbons. This brings out the great importance of the starting oils in conversion toward products which are desired. The type of hydrocarbons present in the oil is of the greatest significance in all catalytic, thermal and pressure decomposition work. And, it is certain that there are many crude oils which do not lend themselves readily to yields of importance of low boiling-point hydrocarbons.

In other words greater conversion has taken place in the higher boiling-point constituents, leaving compounds present in the same distillation cut of different composition, lower specific gravity and index of refraction than at first. Furthermore, the fractions above this one considered have broken down in turn to give com-

¹⁰ Rittman and Egloff, *Jour. Ind. Chem. Eng.*, 7, 181, 1915.

pounds in the lower boiling cuts which also affect the physical constants. This change may be thought to be taking place in all six oils but as the higher fractions are less stable to the action of aluminium chloride than the lower boiling fractions a relatively greater difference in the physical properties would be manifested and our comparison is inverse to the usual experience in thermal and pressure decomposition of oils which although not strictly comparable, yet may be used as a means of analogy.

F. THE EFFECT OF ALUMINIUM CHLORIDE ON THE FORMATION OF GASOLINE FROM THE SIX FRACTIONS OF A NAPHTHENE BASE OIL, IN THE RECOVERED OIL

The effect of aluminium chloride upon gasoline formation in the recovered oil indicates a minimum in the fraction number two of 23.5 per cent and a maximum yield in fraction five of 47.3 per cent. A minimum is also shown in fraction six of 44.5 per cent of gasoline in the recovered oil. The oil distilling below 150 deg. C. has been taken as the gasoline cut. The analytical results are shown in Fig. 2. The specific gravity and the refractive index of these gasoline cuts, in particular that part boiling up to 95 deg. C., show a very high percentage of paraffins. The oils number 4 and 6 yield practically pure hexane and heptane.

G. THE EFFECT OF ALUMINIUM CHLORIDE ON THE FORMATION OF GASOLINE AND THE SPECIFIC GRAVITY OF THE GASOLINE FROM THE SIX FRACTIONS, ON BASIS OF OIL USED FOR PRODUCTION

The important point in gasoline formation is the question of how many gallons of gasoline can be produced from 100 gal. of starting oil. The two factors entering in the percentage of gasoline on the basis of oil used for production are the percentage of recovered oil after aluminium chloride treatment and the percentage of gasoline present in the recovered oil after treatment.

In this series of experiments the highest boiling point fraction number six, gave the greatest amount of decomposition of the starting oil for the production of gasoline upon basis of oil used for production, the percentage being 32.1, that is, the formation of 32 1/10 gal. of gasoline from every 100 gal. used. The lowest yield was 18.4 per cent from fraction two. From fraction two to six increasing amounts of gasoline were formed with the maximum in fraction six. In Fig. 3 the results are given in graphical form.

The physical constant specific gravity gives some indication as to the value of a gasoline, although it seems to the authors that in the past too much emphasis has been placed upon this constant as a criterion by which to judge the value of an oil as a motor fuel. Happily, for the modern cracking processes, most of which furnish some percentage of aromatics, the tendency is to lay less stress on the specific gravity of gasoline. All the data upon the conversion of heavier hydrocarbons to lighter boiling-point hydrocarbons from thermal and pressure decomposition or by the action of catalysts or chemical reagent seem to show the formation not alone of aliphatic hydrocarbons but also aromatic. As the specific gravity of the aromatic compounds is much higher than that of the aliphatic hydrocarbons, naturally gasoline formed by the above methods of preparation must be higher in specific gravity than gasoline derived by simple distillation of a crude oil at atmospheric pressure.

However, the mixture of aliphatic and aromatic hydrocarbons does not lessen the value of the oil as a motor fuel although the specific gravity of a gasoline de-

rived from a converted oil is greater than that of a gasoline derived by simple distillation from a crude oil. The specific gravity of the gasoline cuts from the converted six fractions ranged from 0.726 to 0.801. Fraction six gave the lowest specific gravity and refractive index with the highest yield of gasoline of the six fractions. Fraction six was the highest boiling point oil of the six fractions having a distillation value boiling point mainly above 300 deg. C., which would indicate that in this type of oil the higher boiling-point oils lend themselves more readily to decomposition than lower boiling-point compounds.

H. THE FORMATION OF BENZENE, TOLUENE AND XYLENE FROM THE ACTION OF ALUMINIUM CHLORIDE ON THE SIX FRACTIONS

The formation of benzene occurred in fraction one and two only. The method of testing for benzene was by the simple one of addition of a sulphuric-nitric acid mixture and nitrating to mononitrobenzene, and determining its physical constants. No test for benzene was found for the cuts derived from fractions three to six inclusive. It is apparent that under the conditions of the experiment benzene was not formed in four fractions; this could only be due to the toluene and xylene which were formed not being in the sphere of the reaction a sufficiently long time, for it is well known that aluminium chloride and toluene or xylene will react so as to form not alone benzene but higher methyl derivatives of benzene. The reaction being a strictly reversible one.



The formation of toluene was found to be at a maximum in fraction one which fraction had the lowest boiling-point hydrocarbons of all the fractions. The minimum formation of toluene was derived from fraction six. The toluene present in the fractions was identified as the mononitrotoluene with its physical constants.

The maximum formation of xylene was obtained in fraction one, 9.8 per cent being formed, with decreasing percentage from fraction one to six. The high percentage in fraction one would indicate that this fraction was particularly adapted for the formation of aromatics as maximum yields were found in this fraction. Fraction one boiled mainly between the temperature of 150 deg. to 200 deg. C., containing naphthenes with aliphatic side chains which decomposed readily to form aromatic of the benzene series, and also hydrocarbons of much higher molecular weight than the starting oil. The total aromatic formation of benzene, toluene and

TABLE 28.

Temperature of lowest boiling constituent in the original fraction in degrees Centigrade . . .	150	175	200	225	250	275
Fraction No.	1	2	3	4	5	6
Per cent of the total aromatics benzene, toluene and xylene on the basis of recovered oil	13.74	10.59	6.70	5.91	5.31	2.26

xylene was 13.74 per cent in fraction one, which was the maximum formation. The percent of total aromatics decreased to a minimum of 2.26 in fraction six. do the low boiling fractions, but go more toward the aliphatic low-boiling hydrocarbons, low specific and re-

The higher boiling-point fractions do not form aromatic hydrocarbons of the benzene series so readily as fractive index under the conditions of the experiments.

Table 28 gives the total percent of the aromatics benzene, toluene and xylene in the recovered oil.

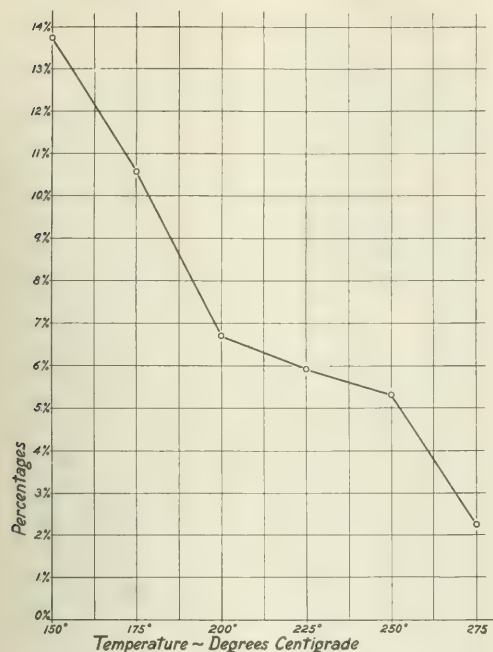


FIG. 7.—THE TOTAL PER CENT OF AROMATICS, BENZENE, TOLUENE AND XYLENE ON BASIS OF RECOVERED OIL

A decrease is to be noted in the total aromatic formation in the recovered oil as the fractions increase from one to six. The data is expressed in Fig. 7.

I. THE FORMATION OF BENZENE, TOLUENE AND XYLENE FROM THE ACTION OF ALUMINIUM CHLORIDE ON SIX FRACTIONS OF A NAPHTHENE BASE OIL, ON BASIS OF OIL USED FOR PRODUCTION

The formation of benzene on the basis of original oil used was found to be at a maximum in oil number two of 1.11 per cent. The toluene and xylene both gave a maximum in fraction one of 2.35 per cent for toluene and 7.8 for xylene. The toluene formation decreased from fraction one to three and increased in fraction four to 1.94 per cent, when another decrease occurred in its formation in fraction five and six. The formation of xylene decreased consistently as the fractions in-

TABLE 29.

Temperature of lowest boiling constituent in the original fraction in degrees Centigrade.....	150	175	200	225	250	275
Fraction No.	1	2	3	4	5	6
Per cent of the total aromatics, benzene, toluene and xylene on the basis of oil used for production	10.93	8.29	5.16	3.95	2.59	1.62

creased from lower to higher boiling constituents. The maximum formation of xylene was in fraction one of 7.8 per cent and the minimum formation of 0.88 in fraction six.

The maximum formation of combined aromatics on basis of oil used was obtained in fraction one, giving a percentage of 10.93. Table 29 gives the total aromatic hydrocarbon formation of benzene, toluene and xylene on the basis of oil used for production.

Fig. 5 gives in graphical form the data of benzene, toluene and xylene formation on basis of oil used.

J. THE SPECIFIC GRAVITY OF THE BENZENE, TOLUENE AND XYLENE CUTS RESULTING FROM THE CONVERSION OF THE SIX OILS

The physical constant of specific gravity is an excellent value for determining the per cent of benzene, toluene and xylene present in a cut when the oil is fractionated by means of a Hempel or Glinsky or other efficient distilling head.

The specific gravity of the benzene cut in fraction two gave a maximum of 0.771. In fractions three to six inclusive no benzene was formed, the cuts were mainly aliphatic hydrocarbons. From previous experimental work the specific gravity of the aliphatic hydrocarbons was found to average 0.720, while the specific gravity of the benzene has been taken as 0.880 at 15.5 deg. C. By simple calculation the amount of benzene present in the cut can be determined. Moreover each cut of the six fractions had been nitrated and the benzene present determined as nitrobenzene.

In the toluene cut of 95 deg. to 120 deg. C. the maximum in the specific gravity value was found to be in fraction two and minima in one and six. Similar to the method for calculating the percentage of benzene present in the cut, toluene may likewise be determined, for the average specific gravity of the toluene cut has been found to be 0.773 for the aliphatic hydrocarbons present. The value for pure toluene has been taken as 0.872 at 15.5 deg. C. Furthermore the toluene was experimentally determined as mononitrotoluene.

The maximum specific gravity of the xylene cut was found to be in number two, amounting to 0.814. The assumed specific gravity of the xylene cut for the aliphatic hydrocarbons present was calculated from specific gravity tables of the paraffin and olefin series hydrocarbons present in the cut from 120 deg. to 150 deg. C. and the average was found to be 0.760. The specific gravity of the xylenes averaged 0.870.

The purity of the benzene, toluene and xylenes in the cuts can be determined from a knowledge of the specific gravity of the cuts. It is to be noted that the specific gravity of the benzene, toluene and xylene cuts reach a maximum in fraction two.

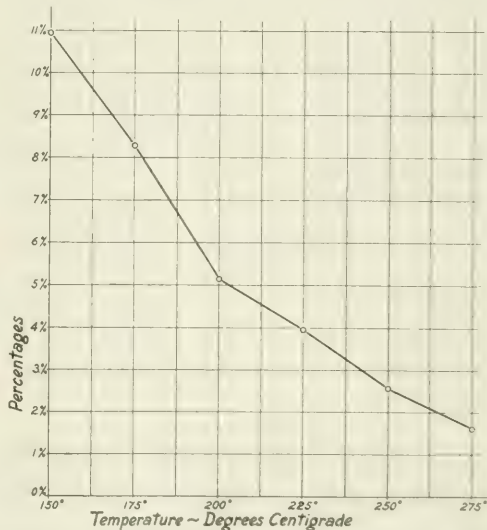


FIG. 8.—THE TOTAL PER CENT OF AROMATICS, BENZENE, TOLUENE AND XYLENE ON THE BASIS OF THE OIL USED FOR PRODUCTION

K. THE PERCENTAGE OF OLEFINS IN THE DISTILLATION CUTS AFTER CONVERSION OF THE SIX OILS

The percentage of olefins present in the cuts 95 deg., 95 deg. to 120 deg., and 120 deg. to 150 deg. C. was found to be practically zero. The gasoline cut to 150 deg. C. gave no olefins, was water-white and gave slight aromatic odor. In the distillation cuts above 150 deg. C. varying percentages of unsaturation were found to be present in the six oils, ranging from 1.6 to 10 per cent. The analytical results are given in table 20.

L. THE PERCENTAGE NITRATED IN THE DISTILLATION CUTS AFTER CONVERSION OF THE SIX OILS

According to the nitration values in table 21 the maximum values occurred in the xylene fraction of the cut of 120 deg. to 150 deg. C. of the six converted oils. This indicates the ready formation of xylene in comparison with higher or lower aliphatic derivatives of benzene. The tri-methyl benzene cut of 150 deg. to 200 deg. C. gave also high nitration percentage in the cuts. No indication could be gleaned as to the formation of naphthalene or anthracene from sulphonation, nitration, distillation, specific gravity, or refractive index tests upon the distillation cuts, although one would expect some formation from the polycyclic naphthenes present in the oil. There is a strong probability, however, of the formation of polycyclic aromatic hydrocarbons under suitable conditions of aluminium chloride treatment.

M. THE COMPARISON OF THE PERCENTAGE UNSATURATED, PERCENTAGE NITRATED AND PERCENTAGE UNATTACKED IN THE DISTILLATION CUTS OF THE ORIGINAL OILS AND THE DISTILLATION CUTS OF THE CONVERTED OILS

The gasoline fractions of the converted oils were with one exception free from olefins. A comparison of the individual distillation cuts on oils 1, 2, 3 and 4 shows a marked decrease in percent olefins after conversion. Oil No. 5 is exceptional in showing an increase in unsaturation of the distillation cuts yielding olefin formation even in the gasoline cut. For the entire converted oils the combined percentage unsaturation is higher than on the starting oils. The higher boiling fractions show rather marked stability toward the acid reagents and consist of naphthene hydrocarbons.

The percentage of the six oils nitrated in the distillation cuts after conversion is lower in all cases except one. This exception is noted in distillation cut of 175 deg. C. to 200 deg. C. in oil No. 1. The percentage decrease of nitratable hydrocarbons after conversion ranges between 73 to 454 per cent. This is in direct accord with the values found for the percentage of unsaturated compounds present in the distillation cuts after conversion. In other words, the action of aluminium chloride upon a naphthene base oil forms more stable hydrocarbons toward the reagents concentrated sulphuric and nitric acid. This property of the aluminium chloride should produce from high-boiling hydrocarbons of the naphthene base oil, lubricating oils of peculiar excellence, consisting mainly of stable naphthenes.

Summary

1. A naphthene base oil was subjected to fractionation of approximately 28 per cent of the total in six distillation cuts. These were distilled in 25 deg. C. cuts and their physical constants determined. They were then analyzed for the percentage of unsaturated, percentage of nitratable hydrocarbons, and the specific gravity and refractive index of the hydrocarbons unattacked by sulphuric and nitric acid were determined.

2. The six oils after treatment with aluminium chloride gave from 24.3 to 60.2 per cent yield of hydrocarbons boiling below the lowest boiling point constituent of the starting oil. The maximum conversion was in the highest boiling point oil.

3. The percentage of oil recovered after aluminium chloride treatment ranged between 60 and 79.3 per cent, the balance of the oil going to gas, carbon and losses due to neutralizing, washing and drying.

4. The specific gravity and the refractive index of the recovered oil was in each case lower than the starting oil, the greatest change taking place in the highest boiling fraction. This oil before treatment gave a specific gravity of 0.849; after conversion 0.774. A similar drop is to be noted in the refractive index of the oil.

5. The specific gravity and refractive index of the distillation cuts of the converted oils decrease as the boiling points of the starting oils increase.

6. The percentage of gasoline in the recovered oil ranged between 23.5 and 47.3 per cent. The gasoline formed was water-white, faintly aromatic and contained practically no unsaturated hydrocarbons.

7. The maximum percentage of gasoline on the basis of 100 gal. of oil used was found in the highest boiling point oil used and gave 32.1 per cent. The formation of gasoline from the six oils ranged between 18.4 and 32.1 per cent on basis of oil used for production. The highest percentage of gasoline converted from the highest boiling point starting oil gave the lowest specific gravity of 0.726. The specific gravity of the other gasoline cuts ranged between 0.726 and 0.801.

8. The formation of toluene and xylene reached a maximum in the recovered oil from the lowest boiling point starting oil, while benzene reached a maximum in the second lowest boiling point starting oil. These maxima were as follows on the basis of oil used for production; for benzene 1.11, for toluene 2.35 and xylene 7.80 per cent.

9. The percentage of unsaturated hydrocarbons in the oils before treatment was usually higher for the same distillation cut than in the converted oils. The maximum unsaturation in any distillation cut of the starting oils was 8.3 per cent while 10 per cent was the maximum in any distillation cut after conversion.

10. The percentage of nitratable hydrocarbons in the distillation cuts after conversion by aluminium chloride decreases as the boiling points of the starting oils increase. The percentage nitratable in the distillation cuts gave values ranging between zero and 43.6 per cent. These values were lower than any similar distillation cut before conversion. The high percentages of the nitratable hydrocarbons in the original oils is impressive, the distillation cut between 150 deg. and 175 deg. C. giving a value of 54.9 per cent.

11. The percentage of the stable hydrocarbons remaining after sulphonation and nitration in every case was greater in the converted oil.

Department of Inorganic Chemistry,
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Fuel Oil Appliances.—The W. S. Rockwell Company, 50 Church Street, New York City, has recently issued an attractive catalog on fuel oil appliances. A general discussion of oil burners is given together with descriptions of the various types of burners, pumps, and other accessory apparatus manufactured by this company. Blowers, tanks, strainers, valves, gauges, steam separators, and steam blowers, are also described. The catalog should prove of value to those interested in fuel oil furnaces and in the storage and handling of fuel oil.

Aluminium Castings and Forgings*

BY P. E. MCKINNEY

In the manufacture of light castings the following properties might be cited as most desirable:

- (a) Low specific gravity.
- (b) A fair amount of strength and freedom from brittleness.
- (c) Good machining properties.
- (d) The maximum resistance to corrosion.
- (e) Good casting qualities and freedom from hot shortness.

It is a well-known fact that pure aluminium is entirely too soft to produce satisfactory castings for most purposes and it is the universal practice to stiffen up the alloy with some hardening element.

Probably the most widely used hardener for aluminium is copper, which is used at the rate of about 8 per cent of copper to 92 per cent of aluminium. Zinc and tin are also frequently used as hardeners.

The use of these hardeners is attended with some well-recognized objections. In the first place, the addition of from 8 per cent to 10 per cent of hardener partially defeats the purpose of using aluminium in that the specific gravity is materially increased. The hardened metal while fairly strong has a strong tendency to brittleness and the alloys are in most cases less resistant to corrosion than either of the component metals. Hot shortness in the case of intricate castings is another feature attendant to the use of these hardeners.

In the Ninth Annual Report of the Alloys Research Committee Dr. W. Rosenhain and Mr. F. C. A. H. Lantberry have published some very interesting data on the influence of manganese on aluminium alloys, which demonstrate beyond a doubt that these combinations have great promise in the production of light alloys. Various combinations containing manganese with or without copper and with a minimum aluminium content of 95 per cent have been used in actual foundry practices for the past two years with the most gratifying results. The use of manganese in relatively small quantities hardens and strengthens the alloy without destroying its ductility as is the case with copper or zinc. The machining properties are excellent and the comparatively small amount of hardener used makes possible a specific gravity in the finished alloy from 0.35 to 0.40 less than that of the ordinary No. 8 alloy. When properly made these alloys are practically free from hot shortness and the most intricate castings can be produced with comparative ease.

The statement has frequently been made that for the successful production of good aluminium alloys it is necessary to have available special melting furnaces and devices for handling the metal. This has not been found to be the case in handling the alloys of aluminium containing manganese which can be melted in natural draft pit furnaces, provided ordinary precautions are used in melting and fluxing the metal. The most satisfactory method of introducing the hardening elements is first, by alloying them with a small amount of aluminium, making a rich hardener of definite proportions and comparatively low melting point.

The most dangerous impurities encountered in aluminium alloys are carbon, silicon and iron, hence, the greatest precaution should be taken to prevent introduction of these impurities either in the metal used or through the medium of crucibles and tools. With this in view carbonless manganese produced by the thernit process has been used exclusively for this purpose. This is alloyed with copper when aluminium-copper-man-

ganese is being made by melting 60 per cent copper and introducing 40 per cent of manganese in small pieces, heating until the two metals have combined, which is seen by the smooth condition of the surface of the metal. This alloy can then be diluted with an equal weight of aluminium to reduce the melting point although it is perfectly feasible to use copper-manganese direct. In making the alloy of manganese without copper 80 per cent aluminium is first melted, brought to a bright cherry red and 20 per cent manganese added in very small pieces. The alloy should be poured as soon as the manganese is all dissolved.

In melting aluminium alloys clay crucibles or clay-lined crucibles are preferable. No charcoal or carbonaceous covering is used on the metal as carbon combines with this alloy forming a very brittle compound. Gates and sprues from castings must be carefully cleaned and freed from sand as practically all the sand introduced into the pot is reduced to silicon which materially weakens the alloy. In cases where there is danger of introducing sand into the crucible it has been found very beneficial to introduce a powdered flux which is made by melting together 60 per cent of potassium chloride and 40 per cent of kryolite and powdering the mixture. This flux tends to dissolve the silica and keeps it from combining with the aluminium.

In preparing the alloy for casting purposes an empty crucible is set in the furnace and heated to a bright red heat. The requisite amount of hardening alloy is added and melted as quickly as possible. As soon as the hardener is melted the draft is cut down by opening the cover of the furnace and aluminium is added in small increments as fast as it will melt, timing the additions so as to keep the temperature of the mixture at not more than a faint red heat. The crucible is drawn from the furnace just before the last of the aluminium is melted in order to prevent the metal becoming overheated. This is a very important point as overheated aluminium will absorb silica from the walls of the crucible at a very rapid rate and it has been found that once overheated this aluminium is practically worthless for future use. Just before pouring there is added to contents of crucible about $\frac{1}{4}$ oz. zinc chloride and the metal is thoroughly stirred with a clay-covered skimmer. This zinc salt tends to reduce the oxides and dross in the metal and puts it in ideal condition for casting purposes. Alloys of aluminium containing manganese have a slightly greater shrinkage than those containing copper alone, and due allowance must be made by using simple risers and chill plates on intricate castings.

The following are results of tensile tests of coupons from sand cast aluminium castings taken at random from recent heats:

Composition: Manganese, 1.50 per cent, copper, 2.00 per cent; aluminium, 96.00 per cent.

Tensile Strength, Lb. Per Sq. In.	Elongation Per Cent in 2 in.
22,000	15.0
22,000	14.0
21,000	8.0
19,000	9.5
19,000	14.7
19,000	14.0
21,000	13.0
22,000	12.0
21,000	10.0
19,000	12.0
18,000	13.0

The elastic ratio of this alloy as determined by the drop of the beam of the testing machine will average about 60 per cent of ultimate strength.

The fracture of test specimens is silky and shows considerable toughness instead of being granular and brittle as is the case with many aluminium alloys. Castings are practically free from hot shortness and it has

*A paper read at the Cleveland meeting of the American Institute of Metals.

been found to be perfectly feasible to make castings with very thin webs without any trouble due to this cause. Alloys of aluminium containing manganese have found to work very freely either by cold rolling or hot forging and many intricate shaped drop forgings have been produced by its use.

In preparing the alloy for forging purposes the same precautions are observed in melting and pouring the ingots as in the case of sand castings. The same type of ingot molds as are used for bronze forging ingots are suitable for aluminium. The ingot molds are heated to about 500 deg. Fahr. and given a thin coating of orange shellac to produce a clean skin. The metal should be carefully skimmed and poured very quickly in order to prevent cold shots due to the low temperature at which it must be poured.

In making drop forgings from aluminium a little preliminary forging is very desirable. The ingot can be cut or cropped to the desired lengths and forged to approximate shape at a temperature of from 1150 deg. Fahr. to 1400 deg. Fahr., after which they can be finished in the dies. These alloys flow with ease during forging and dies have been found to fill very nicely in all cases. Forging dies of the same type as are used for tobin bronze forgings are perfectly satisfactory for aluminium work.

The stiffness and strength of the forged material can be controlled by varying the finishing temperature. Considerable stiffness and elasticity can be imparted to the forgings by two or three blows of the forging dies at about 500 deg. Fahr.

The following are typical physical properties obtained on bars of this alloy forged to 1 in. square and turned to standard size tensile specimens.

Soft alloy containing:

Manganese 1.00 per cent, copper 2.00 per cent, aluminium, 96.50 per cent.

	Tensile Strength	Yield Point	Elongation	Reduction
Cold finished.....	27,750	27,750	12.00	47.00
Hot finished.....	21,083	12,223	26.7	48.7
Intermediate.....	25,617	22,918	17.4	52.00

Hard alloy containing:

Manganese 2.00 per cent, copper 3.00 per cent, aluminium, 94.50 per cent.

	Tensile Strength	Yield Point	Elongation	Reduction
Cold finished.....	31,930	30,000	9.75	35.3
Cold finished.....	34,123	33,000	4.00	11.25
Cold finished.....	30,405	30,000	11.25	30.78
Hot finished.....	27,450	15,000	21.95	56.0
Intermediate.....	28,670	22,000	21.00	50.4

Sections cut from thin drop forgings which were cold finished have shown tensile strength as high as 40,000 lb. per square inch. The forged material machines very nicely and shows a fine silky fracture when broken. The increased density of the metal produced by forging makes it a great deal more resistant to sea water corrosion than the cast alloy. Several drop forgings of these alloys are now undergoing service tests on ships at sea to determine their resistance to corrosion and reports thus far received are very promising.

Considering the low specific gravity of these alloys together with the strength and ductility obtainable the material compares very favorably with the heavier bronze and brass forging materials for many purposes.

U. S. Naval Gun Factory,
Washington, D. C.

Canadian Nickel Refinery.—The new electrolytic nickel refining plant at Niagara Falls, Ontario, was expected to be finished Sept. 1. The province of Ontario expects to refine its nickel at home when the plant is finished.

Alloys to Withstand Internal Air Pressure*

BY S. D. SLEETH

At the request of Mr. Clamer I have attempted to set forth what we might term a few observations upon the subject of "alloys to withstand internal air pressure." Brass and bronzes have as a rule been recognized as metals adapted especially for this purpose, and this paper will, therefore, be confined to the use of such alloys. Density and strength are the two qualities that go to make up a metal suitable for the retention of air or other gases under pressure and while strength may be secured through proper design, density is that elusive will-o'-the-wisp which we chase for a while in one direction and think we have captured, only to find that it has eluded us and we must look for it elsewhere.

This leads us then to the conclusion that there can be no hard and fast rule whereby this desirable quality of density can always be obtained, probably because of the fact that there are so many variables that enter into the process and that they cannot always be under our control. To enumerate some of these variables, we have the design of the article to be cast, the design of the pattern with reference to its position in the flask, composition of the alloy, the treatment of the metal in the furnaces, and the temperature of the metal when being poured. Each item in this list is worthy of extended discussion, but time will not permit of more than a cursory glance at each subject.

We shall begin with the design of the article to be cast. This has a very important bearing upon the ultimate success of the casting. The designer should bear in mind the desirability of having all cross-sections of approximately equal thickness in order to prevent draws at heavy portions. If this is not possible, access to all large sections should be allowed for the use of chills to prevent such draws. If the cored cavities are large the cores will, themselves, act as chills. Fillets should be as small as possible in order that excessive masses of metal shall not be concentrated all at one point.

In laying out patterns, the patternmaker must be governed by several things. He must know what chills are to be used so that large chilled surfaces may be placed in a vertical position in order to prevent the metal kicking off these surfaces. He must know what parts are to be clean, such as valve seats, etc., and to what parts loose sand may be allowed to flow if any be found in the mould. Such unimportant parts should be placed high in the cope and the loose sand will flow to them on top of the metal. A clean mould, however, is absolutely essential to good tight castings. An exceptionally clean casting may be obtained by gating it from another casting which will itself take all the dirt.

On the use of chills, I might state as an almost universal law: Use chills on all enlarged sections in close proximity to smaller sections and connected thereto. If the sections are exceptionally large, use a sinking head on top of the large sections. Gate your moulds with a heavy upright pouring gate as near to the pattern as possible. The gate leading from the pouring gate to the pattern should be made large at the pouring gate and then reduced sharply into the pattern. If it is large where it joins the pattern, in all probability it will show a draw in the casting at the gate. As a rule, it is better to gate in a light part of the casting than in a heavy portion. If a sinking head be used it should be placed on the heavy part.

As regards the alloy to be used, the following com-

*A paper presented at the Cleveland meeting of the American Institute of Metals on Sept. 13, 1916.

positions have been tried and found satisfactory for the purpose intended:

Metals	No. 1 Alloy	No. 2 Alloy	No. 3 Alloy
Copper	72.50%	82.00%	83.00%
Tin	1.75%	7.50%	11.50%
Zinc	19.25%	4.75%	4.00%
Lead	6.50%	5.75%	1.50%
Total	100.00%	100.00%	100.00%

No. 1 alloy is used for ordinary castings, such as cocks, pistons, bushings, etc. This alloy is easily machined, but is not intended for use with very high pressures.

No. 2 and No. 3 alloys are intended for use with high pressures and are harder to machine in proportion.

As might be expected, the treatment of the metal in the furnaces is of vital importance. If proper allowance for oxidation of zinc, etc., is not made the alloy intended will not be produced. Furthermore, the metal must be taken from the furnace as soon as it reaches the proper heat, for if allowed to soak in the furnace it will take up gases and the castings made from it may be porous. In certain packing ring mixtures we consider this item so important that we use an alarm clock to insure the metal being poured off at exactly the proper moment.

The temperature at which the metal should be poured into the moulds is important, and no doubt many castings are lost due to carelessness in this matter. If poured too cold it is almost impossible to obtain solid castings, especially at the gate. On the other hand, if poured too hot, the castings may be porous throughout. Great care must be taken to see that no aluminium gets into the mixture, as very small percentage of it will cause the castings to leak. Antimony and iron will do the same, but not to so great an extent. Aluminium has a very peculiar action on the metal. The castings will look solid and will not show a draw, but when put under pressure will leak all over. It is one of the most dangerous metals around the brass foundry. Antimony does not act as quickly as aluminium, but has about the same effect if used long enough in the mixture. You may start out with a small percentage and it seems to do no harm, but if used until it is mixed with all returned material, such as turnings, gates, etc., the castings will become porous.

In conclusion, let me say that solid castings of a density to withstand air pressure can be obtained only by the exercise of the greatest care from the design of the article to the pouring of the metal into the mould. Even then failures will sometimes happen and final success can be obtained only through experiment and the adaptation of the various methods to the article under consideration.

Westinghouse Air Brake Co.

The Determination of Sulfuric Anhydrid

BY EDWIN G. PIERCE

Some methods for cement analysis, worked out to secure the greatest possible accuracy, exceed the degree of precision required for routine and control work. The writer has pointed out¹ that the use of the reflux condenser in the Newberry, or "acid and alkali" lime determination is unnecessary and involves considerable loss of time.

In the determination of sulfuric anhydrid, specifications usually require that the precipitated barium sulfate, shall stand five hours before filtering, and this seems to be a well-chosen period. The following shorter method, however, will consistently give the same result,

within a few hundredths, and allow the analyst to complete a routine cement analysis (excepting the magnesia) in four hours. It is equally applicable to the precipitation of barium sulfate in any other industrial analysis.

Preliminary Observations

Filtrates from barium sulfate separations, allowed to stand for varying periods, and stirred with a centrifugal motion, always showed some precipitate collecting in the center, indicating that the determination as ordinarily carried out with commercial papers is at best only approximately correct. Various papers and changes in the method were tried, but always some sulfate would appear in the filtrate. Next, the filtrate was collected in three portions, viz.: (a) the supernatant liquid, (b) the filtrate secured while bringing the precipitate upon the paper, and (c) the wash water. In nearly all cases less precipitate appeared in (a) than in (b) and (c), showing that precipitation was complete, but the sulfate was carried through the paper mechanically.

Theoretical Part

Zsigmondy states² that the crystalloid solubility of barium sulfate is too great to permit its preparation as a colloid, and according to the colloidal theory of P. P. von Weimarn,³ particles of colloidal solutions are all crystalline, and the size of the crystals depends upon concentration, pressure, and temperature conditions.

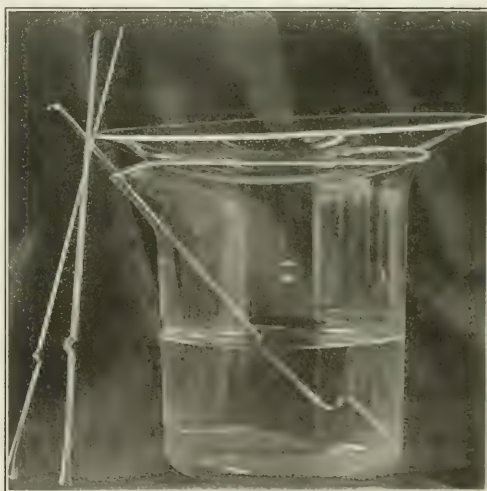
Ostwald⁴ points out that small crystals are more soluble than large ones, hence, when both are present, there will be a condition of supersaturation for larger crystals, causing them to grow; and of hypersaturation for small crystals, causing them to dissolve—high temperatures also increase this solubility.

Lehman, in explaining the process of crystal growth, brings out the following points: When a precipitant is added to a solution at a given point, causing crystals to form, the solution becomes impoverished at that point, tending to the formation of smaller crystals. The growth of crystals is aided by diffusion currents in the liquid by which fresh material is brought in contact with the nucleus. Secondary and tertiary lines of

²Colloids and the ultramicroscope.

³Arbeiten Weimarn.

⁴Lehrbuch der allgemeinen Chemie, 2nd Ed., p. 757.



BEAKER WITH BOILING TUBES

¹Journal of Industrial and Engineering Chemistry, Vol. 7, No. 3, p. 268.

growth shoot off from the parent stems, thus exposing greater surface to the diffusion currents, and causing skeletal outlines to fill out. Growth is retarded by the presence in the solution of layers of different temperatures, which affect pressures and solubilities.

From the above considerations it is evident that to suppress the formation of small, and assist the formation of large crystals from the outset, and to foster the growth of these large crystals at the expense of the small ones, will add to the completeness of the barium sulfate separation.

Description of Short Method

To provide an even distribution of heat throughout the solution, prevent "bumping," diffuse the precipitant rapidly, and constantly reduce the volume of the solution; boiling tubes are used as shown in the illustration. These consist of a capillary tube attached to a stem of convenient length, and give a steady flow of bubbles from the bottom which prevents superheating, and boiling may be continued without direct attention as long as desired.

The boiling barium chloride solution is added very slowly, allowing rapid diffusion, and boiling is continued till the barium sulfate settles to the bottom. The boiling tube is then removed with a quick motion while boiling continues so that no liquid will be drawn into the capillary, and the beaker placed on a sand-bath or hot-plate kept just below the boiling point, and allowed to stand about two hours. The solution is then rapidly cooled and is ready to filter.

From theoretical considerations already mentioned it is evident that a slow paper is preferable, as there will be less suction and less sulfate drawn through while bringing the precipitate upon the paper. The larger crystals and skeletal forms will clog the pores and hold back the smaller crystals, but some particles of small size pass through before this takes place, as shown by an examination of the filtrate.

For the same reason it is best in washing not to disturb the matt of crystals first formed on the paper, but merely circle the top with the stream from the wash-bottle, since, by more violent washing, there is a greater loss of small particles.

In bringing the precipitate upon the paper there can be no advantage in any extensive washing and swabbing of the beaker to remove last traces of barium sulfate, since each additional washing carries more small particles through the paper than will be removed from the beaker.

If the precipitation has been properly carried out and

the barium sulfate settled out perfectly clear, it can be brought upon the paper and the beaker sufficiently rinsed in three applications of the wash-bottle, and with three additional washings of the paper the filtrate will show barely a trace of chlorides. The writer uses double papers requiring three to five minutes to drain. The precipitate secured in this way will ash perfectly white to constant weight at 925 deg. C. in twenty to thirty minutes.

If desired the analyst may easily work out a correction factor, but, with sufficient practice this should be unnecessary for routine work. Whatever period of standing is allowed the boiling tubes will be found a distinct advantage and can be used in other boiling operations.

For greater precision in the separation of barium sulfate, the excellent papers of P. P. von Weimarn¹ give valuable hints.

Table I gives a comparison of results.

Youngstown, Ohio.

Synopsis of Recent Chemical and Metallurgical Literature

Fuel Economy in Great Britain.—A discussion of the necessity of practicing the strictest economy in the utilization of fuel, and some interesting data on the fuel situation in Great Britain were given in a paper by HENRY E. ARMSTRONG, presented at the recent meeting of the Society of Chemical Industry at Edinburgh and published in the July 31 issue of the *Journal of the society*.

The author states that the fuel situation is daily becoming more and more serious. Coal is very expensive, and there is almost an absolute shortage of liquid fuel for internal combustion engines, and the shortage of dyestuffs is partly due to the lack of raw material. It would be advantageous to carbonize far larger quantities in ovens or retorts, and the nuisances created by the emission of smoke and acid products must not be overlooked. The utilization of coal should be considered from the more comprehensive point of view, as the raw material from which both liquid fuel and the primary materials required by the dyestuff industry and other branches of organic chemical industry are derived—not forgetting the high explosives which are playing so dominant a part in the present war; also as the potential source of vast quantities of ammonia, invaluable as a cereal manure, as well as of not a little sulphur.

The author continues as follows: "It is certain that we have little moral right to use coal simply and directly as fuel; from this point of view, should we not memorialize government at once to foreshadow legislation prohibiting the use of raw coal, as a fuel, at no distant date? I am told that the use of raw coal was stopped in Germany at an early period of the war. . . . Soft coke is necessarily to be regarded as the solid fuel of the future; yet if such be the conclusion, a situation will soon be created that must not be overlooked. Obviously if gas and soft coke be the fuels of the future, the town gas industry, as at present conducted, will need complete reconstruction—the gas works will be called upon to produce both gas and soft coke and to serve as the primary source of fuel supply in its district; moreover, it will almost necessarily be run in conjunction with the supply of electricity. Already the Brighton Corporation have made arrangements for the installation of a coking plant alongside their electrical works, the gas to be used in firing the boilers of the latter; it will be but a small departure to obtain an act for-

TABLE I. DETERMINATIONS OF SULFUR ANHYDRIDE

Sample	Boiling Tubes	Time of Solution in H ₂ O	Trace < 1 < 2 < 3 < 4 < 5				Number of Washings	SO ₂ in %
			Residue from Superheated Liquid	Residue from Washing Beaker	Residue in Water			
1	Not used	36	Trace	2	1	5	1	46
	Not used	5	Trace	2	1	2	1	46
	Used	2 1/2	Trace	2	1	3	3	46
2	Not used	12	Trace	3	2	7	1	40
	Not used	5	Trace	1	1	7	1	43
	Used	2 1/2	Trace	2	1	3	1	42
3	Not used	36	1	2	2	5	1	48
	Not used	5	Trace	2	1	7	1	56
	Used	2 1/2	Trace	1	1	3	3	57
4	Not used	36	1	3	3	5	1	57
	Not used	5	Trace	1	1	7	1	61
	Used	2 1/2	Trace	2	1	3	3	60
5	Not used	36	Trace	3	2	7	1	42
	Not used	5	Trace	1	1	7	1	44
	Used	2	Trace	1	1	3	3	44

bidding the use of raw coal in the district which will make the soft coke produced of special value to the town.

"In my Newcastle paper I referred to the production of soft coke as still problematic; I was not then aware what had been done to improve Mr. T. Elwell Parker's process, which gave a coke of unexceptionable quality though on far too small a scale to be practicable. In the interval, a gas fired fireclay oven has been devised in which coking can be effected on a satisfactory scale. I am informed that in Germany probably a dozen such plants are in operation which have been erected since the war began, and that the design of these is based upon information derived from the experiments made in this country. Similar plant will soon be in operation in this country near Barnsley, in the center of the South Yorkshire coal field; this will be run in conjunction with an electrical works and a tar distillery. Such being the case, it would seem that the experimental stage is past and that all that is required is independent study by competent authority of the plants referred to when they are in operation.

"But there are many problems connected with the economical use of coal which must be fully inquired into. It is essential that both the funds and the machinery for such inquiry should be provided without delay. The appointment of a central National Fuel Board to initiate and supervise all necessary inquiries would seem to be the first step that is called for, and I venture to think that no better way of obtaining funds can well be suggested than that I have already proposed—i.e., a small tax on all coal raised in the country. I hope the society will be prepared to take action in the manner suggested."

The paper brought out considerable interesting discussion.

The president, Dr. Charles Carpenter, said that it was very difficult to foresee the universal use of gas or electric heating, and, in the intermediate stage, some form of solid fuel might be used. The breakdown in the coalite experiments had been very unfortunate in many respects. The fundamental idea of Mr. Parker was to carbonize the coal in small cells, and in itself was an admirable one—but when he had put it into practice he was handicapped by the fact that he had been brought up and trained as an iron founder and so naturally turned his thoughts to making his cells in iron.

Dr. E. F. Armstrong urged that there was still a great deal to be done by manufacturers in economizing coal. The best incentive to economy was an increase in price, and from that point of view the present increase—disastrous as it was to many—was a great incentive to economy in the future. The firm with which he was connected had made it a practice for many years to employ a highly skilled chemist entirely to look after their fuel and water supply, and that policy had been more than justified by results. It was a policy worthy of being imitated very largely in British industries, not so much chemical industries, but engineering industries in particular, and by many others of our great industries. He mentioned a case of one firm who had benefited greatly by the installation of a CO₂ recorder. It was only the largest firms who could afford to have an expert for themselves, but it might be possible for half a dozen firms in a neighborhood mutually to engage an expert to look after their fuel and water problems, by which he was sure great economy in utilization might be effected.

Mr. R. H. Clayton said that in Manchester quite recently they had obtained statistics as to what the losses due to smoke amounted to; they were so large that he

thought he was quite justified in the view that the smoke problem was the most important of all fuel questions.

Mr. A. MacDonald asked how the ash in soft coke was to be got rid of. In Glasgow they had been deeply interested in clearing the smoke from the atmosphere, and one member of the Council was experimenting with a view to producing a coke which would be useful for house fires, but he had found that it contained an excessive amount of ash and had low heating power. The same trouble had been found in similar fuel prepared by a small works in London.

Mr. R. Maclaurin said that the fuel to which Mr. MacDonald had referred was made from cannel coal, hence the large percentage of ash. With a coking coal a smokeless fuel containing not more than 7 or 8 per cent of ash was readily obtained. The chief difficulty he had experienced in the experiments he was conducting at the Glasgow Corporation's Electricity Station, Port Dundas, was in getting a fuel that would not spark. The sparking was due to the coke dropping while red hot into water. By drying, or avoiding quenching the coke in water, a satisfactory smokeless fuel was obtained. In the low temperature carbonization of coal by his process very satisfactory yields of oil were being obtained. The oil was fairly fluid, and after separation of a resinous portion would be suitable, he thought, for lubricating purposes or for Diesel engines. The oil contained practically no benzene nor toluene, as was to be expected in a low temperature process. An unexpected result, however, was the almost entire absence of illuminants in the gas made. In some experiments the coal was carbonized by a current of hot water-gas, without any external heating, and he had found that the mixed gas given off from the coal in this way seldom contained more than 0.4 per cent of olefines; had the coal given off 4000 or 5000 cu. ft. of gas of 700 or 800 B.t.u., the olefines should have amounted to fully 4 per cent. In other low temperature processes he was convinced that considerable decomposition took place, giving rise to the illuminants present in such gas. The absence of illuminants in his process convinced him that smokeless fuel would be manufactured more economically in electricity stations than at gas works. His plant was in two parts. When working for power gas and smokeless fuel, air and steam were blown into one chamber where they burned the fuel added to ash, and the gas passed from this chamber into a second chamber, which was practically a large water sealed producer, 30 ft. high by about 8 ft. diameter. The current of hot gas completely carbonized the coal being added to this chamber. The smokeless fuel was drawn out at the bottom through a water seal. In this plant there was no difficulty in carbonizing uniformly 1 ton of coal per hour. The gas made in both chambers, after cooling and scrubbing, was available for gas engine running or boiler firing. When smokeless fuel was not desired the fuel could be burned to ash in both chambers, and gave practically the same yield of power gas as an ordinary producer, but the quantity and quality of the oil recovered were much enhanced.

Mr. J. G. Roberts said that in the pottery trade he did not think there was a plant in existence using gas firing which had been an unqualified success. The two biggest plants that he knew of had been abandoned. For pottery firing a long and intensely hot flame was needed, and good coal was required to get that flame. The regenerative system of heating had not been profitably applied to the heating of pottery and the expense of repairs became very great.

Mr. W. F. Reid said that he thought the prohibition of the use of solid fuel was quite impracticable at pres-

ent. Public opinion was not yet ripe for that. They must first try to educate public opinion to the great evils and probably the injury to health due to the consumption of coal. A great deal had been done in reducing the amount of smoke from coal. As a member of the Council of the Coal Smoke Prevention Association, he said that they were quite satisfied with the progress that had been made in London and other large cities—especially with regard to the elimination of fogs in London. The use of more gas had had some influence, but so also had the expression of public opinion and in a few cases the action taken by local authorities. Dr. Haldane had recently pronounced the opinion that the particles of carbon contained in smoke were distinctly beneficial to the lungs of those who breathed them, and he was now endeavoring to prove that it was beneficial to inhale particles of carbon to prevent tuberculosis. His own belief was that it was the tarry substances that were so injurious.

Mr. W. F. Cooper expressed the opinion that the trouble really was that there was no one in Parliament who really understood the subject.

Dr. J. T. Dunn said that some progress would be achieved if consumers as a body could be persuaded that it would pay them to buy coal on a calorific basis. Good coal was high in price, but with ordinary inferior coals, the price diminished very rapidly, so that it did not pay to sell the latter. That was the reason why those coals were not in many instances worked. Sale on a calorific basis would, he thought, enable colliery owners to work those at present unworked portions of the seams with greater prospects of getting some remunerative price. There were many advantages in low temperature carbonization processes, but it was not possible to have all the advantages at once. In the ordinary process of gasworks, a very small proportion of the nitrogen was recovered, but low temperature processes, where the solid fuel produced was burnt directly, as in domestic grates, recovered a smaller proportion still. If, however, the solid fuel was consumed in a low temperature gas producer, a greatly increased yield of ammonia could be obtained.

Mr. W. J. Rees agreed that the purchase or sale of coal on a calorific basis would be advantageous. He did not think it was the purchaser but the colliery proprietor who stood in the way in that connection. If such a scheme could be brought into operation successfully, it would be to the mutual benefit both of the colliery owner and the user of the coal.

The president remarked that the origin of Dr. Haldane's experiments was that he had found that miners as a class were particularly free from tuberculosis, and having regard to the dusty conditions in which they were working, he was led to believe it might be due to the coal dust. The fog question was more important still. The fog caused the rise in mortality, and the discomfort, and he thought that most of the troubles arising from the imperfect combustion of coal were not due to "smuts," but to the products of distillation.

Professor Armstrong in reply said that he wished to make it clear to this society that it had a mission which it could fulfill. There was now a golden opportunity for it to take up this subject and make it their own. They should be put in a position to approach Parliament on the subject and urge our views upon them. The whole subject must be dealt with from a practical point of view and proved by results. Great credit was due to a man like Mr. Elwell Parker for conceiving the idea and spending so much time in experiments on a subject of which he knew nothing—that was the type of man who started things in this country; but some concerted effort should now be made to work the prob-

lems out. They could be worked out in a very few years, he was sure. The original coalite process was a low temperature process conducted in such a way that the products were carried off immediately, and there was practically no benzene or toluene in the tar, but a good deal of carbolic acid of much higher quality than was produced in any other way. The real source of benzene in those processes was not the tar but the gas. The gas produced was very rich, and if stripped it gave a satisfactory amount of benzene, leaving gas of a high calorific value which needed dilution to be used for ordinary steam-raising purposes. He now felt highly confident that the work had been taken in hand in such a way that there was every prospect of good results being attained. His own view was that the gas industry ought to take the matter very seriously into consideration.

Influence of the War on British Tar Distillation Industry.—In a paper presented at the recent meeting of the Society of Chemical Industry in Edinburgh, W. H. COLEMAN gives some interesting data as to the present status of the British tar distillation industry. The biggest problem is the disposal of the pitch. The price of this product fell considerably after the war started due to the stoppage of exports. Most of the pitch exported was used in making briquets. Several proposals have been made for utilizing this pitch. One proposal was to mix a proportion of pitch with the coal charged into the gas retorts. It has also been proposed to render non-coking coal fit for coking by adding a proportion of pitch before charging into the ovens. No results on this have been published and it offers little hope since most coking coals lose their coking property when heated to about 400 deg. C. It is possible that low-temperature pitches, such as those obtained from the producer and the blast furnace tars, may be more suitable for this purpose than gas works tar, and coke oven tar. One field which offers considerable promise is the making of briquets. Very large quantities of slack coal are produced and if the slack were washed, the nuts being used for fuel direct and the finer briquetted a greater efficiency will result. Large quantities of coke breeze might also be usefully formed into briquets. Outlets for benzol and toluol have to be found when the demand for explosives ceases. The revival of the color industry will take some, but the balance could be used as motor fuel in admixture with alcohol. Creosote may have a bright future in Diesel type engines. On June 30, 1916, there were 356 tar distillation plants, a very rapid increase having taken place as in 1912 there were only 221. The author suggests the establishment of a central research laboratory, some of the questions to be solved being as follows: The cause of corrosion in tar stills. Is the present method of separating the fractions the best in view of the products required? An investigation of creosote oil and of the lesser known bodies in the distillates with a view to finding uses for them. An investigation of coal gas pitch to find means for rendering it less brittle when cold and raising its melting point, so as to render it, if possible, more suitable for replacing natural asphalt. The standardization of the methods of testing coal tar products. Meetings might also be held from time to time to discuss ways and means of preventing useless competition and conferences might take place with representatives of the gas making and coke oven industries to discuss questions of mutual interest. Many other suggestions might be made but the whole can be summed up by saying that the great need is organization and co-operation, so that advantage may be taken of all opportunities of improving the prospects of the industry.

Progress of Rare Earth Industry in England.—In a Society of Chemical Industry paper presented at the recent Edinburgh meeting, SIDNEY J. JOHNSTONE gives a review of progress in the British rare earth industry. The British industry has undergone several extreme changes during the past two years, varying from a serious shortage of most of the necessary raw materials at the outbreak of the war to a much better present position. England formerly imported practically all of her thorium nitrate used in making incandescent mantles from Germany. At the outbreak of the war these imports ceased and as little was obtainable from France, and practically none from the United States, investigations of sources of monazite sand were undertaken. The only known deposits of monazite sand of any commercial importance at present are those worked on the coast of Brazil and in Travancore, India,* the latter sand being of considerably greater value because of its higher content of thorium. For several years prior to 1914 the whole output of Travancore, amounting to 1300 tons per annum, and equivalent to 2300 tons of the best grade Brazilian sand, has gone to Germany for treatment. The concession for working the deposits was held by a British company, the London Cosmopolitan Mining Co., and the output was sold under contract to a German firm. At present the output is going to the United States and England. During the past year a considerable quantity of Travancore sand was sent to the United States for treatment and many incandescent mantle manufacturers in England have had to depend on supplies of thorium nitrate from this country. In addition to the company mentioned above, another company, called Thorium, Ltd., has recently obtained concessions to work a 150-acre deposit. This company ships its output to London and manufactures thorium nitrate there. Rights to work the Brazilian deposits are mostly held by German firms. Each Brazilian state has a separate export duty. The quantity exported has gradually decreased from 6462 metric tons in 1909 to 1437 metric tons in 1913. Later returns are not available.

The incandescent mantle manufacturers in England use thorium equivalent to about 650 tons of Travancore monazite sand per year. Unless the mantle industry is considerably extended, the important resources of monazite sand will go to other nations, as England is not able at present to use a normal year's output from Travancore. There are several industries using small amounts of thorium, the most important of which is the manufacture of filaments, of an alloy of tungsten and thorium, which was imported from Germany.

Pure cerium compounds, obtained by treating the residue after extracting thorium from monazite, suitable for use in the manufacture of incandescent gas mantles and optical glass, can be obtained in adequate quantity in England, a fair quantity being imported from the United States. Pyrophoric alloys come also from the United States. By an "order in council" dated February 23, 1916, the export of the oxide and salts of cerium, metallic cerium, and its alloys, except ferrocerium, was prohibited to all destinations. Ferrocerium was allowed to go to British Colonies.

Didymium salts, which are obtained from the same source as cerium, and are used for branding incandescent mantles, are imported from the United States.

Tantalum filaments are being made by one firm in England from tantalite. The zirconia which is used is imported from the United States. The author points out that the new British rare earth industries may require government assistance, either direct or indirect, to maintain their position when peace is declared.

Notes on Metallurgical and Chemical Engineering in Great Britain

(By our London Correspondent)

The Ministry of Science

The creation of a Ministry of Science, is a proposed suggestion which has the support of many leading commercial and scientific men in this country.

Professor Donnan, F.R.S. of University College, London, in describing the functions of such a ministry proposes that it should establish national laboratories and "Bureaus" for standardization and testing of materials, and investigations relating to the scientific development of agriculture, the mineral resources of the country; sanitation and public health; pure food supply; and the application of science to military and naval matters.

It would also encourage the higher grade schools and possibly provide schools for the scientific training of journalists "so that there shall be produced men who are able to understand, follow and continuously present the results of scientific technical development and scientific inquiry to the readers of the daily Press." In this last projected activity it would almost seem that we should be more nearly imitating the country always referred to by practical men for the excellence of its technical journals, rather than the one whose scientific attainments have been drummed into our ears for the last seven years—very vigorously for the last two.

The Prussian Educational System

Commenting on the contention that the "Prussian educational system had . . . great virtues," a leader in the *Times* educational supplement for August 1, very pertinently points out that the object of that system is "to produce automata for the service of the state, with the inevitable result that the passions of the victim, which are at least as much the true subjects of education as brain-power, are in restraint waiting and watching for the moment when license becomes possible." Seldom has a more clear-headed summing-up of the real objects of education been made, even though prefaced by the supposition that the object of the Prussian system of education was to produce automata for the service of the state. The fact that education should aim at fitting the subject for contending with the problems and difficulties of life, and that the capacity and time of the subject are limited seems never to penetrate the super-consciousness of the political educationist.

The Daylight Saving Scheme

The ease with which the country has adapted itself to the daylight saving scheme has cast considerable doubt on the validity of the ancient maxim "You cannot make a man virtuous by Act of Parliament." (*Ref. Virtue and Early Rising.*) In view of the hoped for commercial activity in the future, it seems at least arguable that the diatribes of scientific men against our present mixture of weights and measures should be reinforced by the enactments of authority. The condition of the manufacturer who has to transcribe all measurements into a duodecimal system, ending in three places of decimals, is not conducive to getting ahead of the rival who simply passes orders and plans through to his shops without any such preliminary. At present, however, we do not seem to have reached even the stage of appointing a committee on the subject. When this was raised as a query in Parliament at the end of July, the answer was that "the compulsory use (of the metric system) was not under contemplation by the Board of Trade." We may take comfort, however, from the fact that the necessity for some alteration has been

*The deposits in the United States have not been worked for several years, due to severe foreign competition.

noticed by at least one of our legislators in the midst of other pre-occupations.

Electrolytic Hypochlorite

Although the valuable disinfectant and sterilizing properties of solutions containing electrolytic hypochlorite of sodium or magnesium are widely known in the States, and to chemists on this side, they take a considerable time in being discovered commercially. That being so, it is satisfactory to note that the installation for producing electrolytic hypochlorite of magnesium established ten years ago at Poplar, is still supplying the solution and assisting to gain public confidence in its qualities.

The depot distributed last year 73,970 gal. of disinfectant. (Report of the medical officer of health to the Borough of Stepney, Dr. F. W. Alexander, to whom the incidence of the enterprise is principally due.)

Tantalum Used in Interrupter

Apparently the old trouble with the interrupter on the high frequency circuits pertaining to X-ray installations has not yet been entirely overcome, to judge by the continual issue of new forms. A new interrupter was described by Capt. C. E. S. Phillips at a recent meeting of the Physical Society of London. This employs tantalum instead of copper segments, which have the advantage of not retaining a film of mercury, as well as high melting point.

The Society of Chemical Industry

The annual general meeting of the Society of Chemical Industry was held at Edinburgh on July 19, 20, and 21. Dr. Charles Carpenter of the South Metropolitan Gas Company, was re-elected president. In his address he gave attention to the final problem, and the question of state control and organization of the coal resources of the country. The first paper, by Professor Armstrong, was on "Fuel Economy," and the second on "Waste in Coal Production," by Professor Henry Louis.

The general tendency of the conclusion reached was in the direction of central generating stations preferably at the pit mouth for the distribution of energy recovered from coal.

An exhibition showing the progress of certain branches of chemical industry was held at the meeting. This included coal tar colors by the British Dyes, Ltd., and glass and porcelain chemical apparatus by various manufacturers in England and Scotland. A variety of chemicals made in this country were also on exhibition, including alkaloids, oil shale distillation products, cobalt blue (from Canadian ore) and trinitro toluene.

The National Physical Laboratory

The report of the executive committee of the National Physical Laboratory has recently been issued, and shows, as was to be anticipated, that a large amount of the work undertaken has been of a special nature for the government. Particulars of this are naturally not at present for publication. Besides the usual comparison of private instruments with standards, and testing of those required for sub-standards, investigation work not of a confidential nature has been carried on, including an inquiry into means of adequate protection of X-ray workers, in the direction of obtaining the absorption coefficients of materials used for protective purposes. The laboratory was invited to undertake this work by the Council of the Roentgen Society, and arrangements have now been made to do so.

The small tungsten arc lamp of Messrs. Girningham and Mullard made by the Edison & Swan Co. has been adapted, in larger sizes to optical pyrometer work, as a

source of radiation and promises to give very satisfactory results in the saving of time as compared with the use of furnaces.

It is necessary to record the death of Sir William Ramsay on July 23. As many obituary notices will have already reached the States, further record of the widespread regret in scientific and other circles will be superfluous. Sir William Ramsay was a man of many and unexpected accomplishments, and there must be many spheres of activity and usefulness the poorer for his decease.

Market Prices for July, 1916

Copper opened at 103.10.0, being then inclined to fall, and went off gradually till the 6th (£97) after which it fell sharply to £91 on the 7th. On the 10th it had reached £85, and then recovered in two days to £93, but did not retain this price, and showed £88 on the 18th. Again hardening, it had risen to £97 by the 25th and closed at £111.

Tin opened at £172 and was up to £173 by the 6th; it showed weakness on the 11th, but kept somewhere near the £170 mark till the 17th, when it reached £166.10.0, and was down to £163 on the 19th, but recovered, reaching £168.10 on the 21st, but eased off to £166 on the 25th. It subsequently again started rising and closed at £172.

Lead opened at £29.10, and continued easier till the 14th, when it had reached £27; it then recovered to £29.5 by the 19th and closed at £29.

Hematite is quoted 122/6 inland and 140/- export.

Cleveland is quoted 87/6 inland and 95/- to 100/- export.

Scotch Pig.—No prices.

Aluminum cuttings, ton (approximate).....	£110	0	0
Borax, British refined crystal, ton.....	30	0	0
Copper sulphate, ton.....	51	0	0
Ebonite rod, lb.....	3	0	0
India rubber, Para fine, lb.....	2	10	10 1/4
Nicla in original cases, medium.....	3	10	5
Quicksilver, Spanish, bottle.....	17	17	6
Sal-Ammoniac, ton.....	75	0	0
Shallac, cwt.....	5	11	0
Sulphur, sublimed flowers, ton.....	15	0	0
Sulphur, percha, fine, lb.....	5	10	10
Sulphate of ammonia.....	17	15	0

Recent Metallurgical and Chemical Patents

Electrolytic Cleaning of Silver.—According to a patent of JOHN B. HOEN of Philadelphia, Pa. (assigned to The Frank A. Rolling Co., Inc.) silverware may be cleaned by placing it upon a tinned grid in the bottom of a container; the grid being supported by and in metallic connection with a circular zinc electrode. An electrolyte prepared with bicarbonate of soda and common salt is used, with warm or hot water. It is stated that owing to the quick polarization of the tinned wires and the high overvoltage of the tin, the total flow of current from the zinc to the tin when no silverware is present is relatively small. Oxides, sulphides, etc., which constitute the tarnish, are readily reduced. (1,182,173, May 9, 1916.)

Composition for Metal-Coating of Iron.—A combination of a metal with mercury bichloride, to be used as a protective metal coating, is patented by JAMES H. MADDY of New York City, and BRUNO H. SCHUBERT of Weehawken, N. J. The coating material is made by adding 5 parts by weight of mercury bichloride and 10 parts of ammonium chloride to 100 parts of zinc chloride solution, having a strength commercially known as 50 per cent. This solution is mixed with the powdered metal to form a paint or paste, and applied to the surface of the article to be coated by

a brush, and is then melted on by means of a hot blast. A heat sufficient to melt the coating metal will produce the required adhesion of the coating. The composition is applicable to the coating of articles too large to be dipped. (1,183,217, May 16, 1916.)

Use of Ammonium Sulphate in Making Carbon Articles.—According to a patent of ARTHUR T. HINCKLEY of Niagara Falls, N. Y. (assigned to the National Carbon Co., Cleveland, Ohio), the addition of 5 to 15 per cent of ammonium sulphate to a mixture of coke and pitch increases the density of the final product obtained by baking. It also permits of the use of more pitch binder, prevents swelling while baking, and shortens the time required for coking the binder. Carbon articles are usually made by molding, tamping and forcing them into the desired form from a material or mixture consisting of an agglomeration of coke or other carbonaceous material and pitch. The mixture from which the articles are made is prepared by agglomerating coke, coal or other carbonaceous material with pitch, both being preferably in a powdered condition, in a vessel which is heated sufficiently to melt the latter. Sulphur has been used for a considerable time to increase the density of the baked article, but the action is not so marked as with ammonium sulphate, or other sulphates, as mentioned in the present process. (1,192,062, July 25, 1916.)

Finely Crystalline Abrasives.—In the ordinary process of making artificial corundum the fused alumina is built up into a large ingot of from two to five tons in the furnace. The shell of the furnace is removed after the ingot solidifies and then it is broken up and crushed to the various sizes required for abrasive purposes. According to a new method described in a patent of FRANK J. TONE of Niagara Falls (assigned to the Carborundum Co.), the molten material after being brought to a high degree of fluidity is tapped out in small masses and quickly frozen. This quick freezing produces a finely-grained product. It is necessary to remove the product quickly from the furnace by means of a tapping spout. The product made by quick cooling when examined by the naked eye appears exceedingly dense and almost devoid of physical structure. The general average grain size is about 0.1 mm., as compared with an average of 0.5 mm. in the ordinary product. The special features which characterize the finely crystalline product from the regular product of the same chemical composition are: the finer average grain and the more general distribution of the small amount of opaque material (consisting of compounds of iron titanium and silicon) through the mass, and the relatively smaller size of the tabular type of Al_2O_3 crystals showing parting or cleavage lines. The fineness of the grain makes the abrasive more resistant to breaking forces than the larger grain material. (1,192,709, July 25, 1916.)

Aluminous Abrasives from Waste Garnet.—A process for the electric furnace production of abrasives from finely pulverized garnet ore, occurring as waste in garnet works is patented by JOHN DAVENPORT of Brighton, Mass. The process is described as having been performed on almandite from Wilnot, N. H., having the following composition:

Silica	36.90
Alumina	39.84
Iron Oxide	18.80
Calcium oxide	1.65
Magnesium oxide	3.27
Manganese oxide	0.51

100.97

Incidental to the production of the abrasives is the production of ferrosilicon. The process consists in heating the garnet flour in an electric furnace with carbon, with the production of oxide of aluminium and a ferrosilicon alloy. The furnace in which the process is carried out is shown in Fig. 1. It consists of an outer iron shell 1, lined with fire brick and having electrodes 5 and 16 as shown. An opening, 13, is provided for the escape of gases and an opening, 14, for feeding in the charge. The charge, consisting of garnet and powdered coke intimately mixed, is fed into the furnace, which is started in the usual manner. Usually 18 per cent of carbon is added. Alternating current of low voltage is used. The action of the arc rapidly reduces the mixture with which the furnace is charged to a molten state since the pure garnet fuses at the relatively low temperature of about

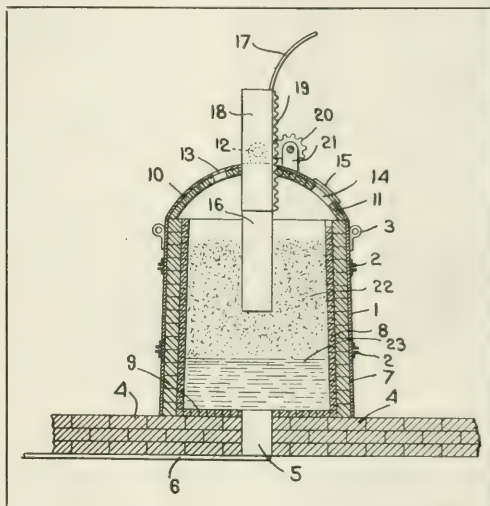


FIG. 1—ELECTRIC FURNACE FOR ABRASIVES AND FERROSILICON

1260 deg. C. The fusing temperature varies with the amount of ferrous impurities contained therein, being lower in proportion to the greater amount of iron contained in the mixture. Additional material may be introduced until a sufficient amount of molten material is found to be present in the furnace. During the reducing operation an active ebullition occurs, considerable gas being driven off. As the reducing operation proceeds the amount of current is gradually increased until the temperature within the furnace reaches the fusing point of alumina, which is approximately 2050 deg. C. When this temperature is reached it is maintained until the constituents other than alumina are entirely reduced and the ebullition ceases. The current is then slowly cut down, gradually decreasing the temperature to permit the slow crystallization of the alumina. It was found that when the molten mixture is cooled rapidly it produces a tough glassy substance which is not properly crystallized and does not form a good abrasive, but that when the molten mass is cooled slowly the alumina becomes crystallized throughout. The ferrosilicon alloy collects in the form of lumps or nodules at the bottom and throughout the mass which may be separated readily from the alumina after the latter is broken. When the entire mass is cooled sufficiently the furnace may be dismantled to

permit the mass to be broken up into pieces of suitable size to be crushed in the usual crushers for abrasants. This may be accomplished by lifting off first the dome, then the iron shell 1, after which the bricks may be removed to expose the solid mass of alumina. This mass may then be broken by sledges or in any suitable manner and afterward run through the crusher and graded. The ferrosilicon may be removed from the crushed material by a gravity separator of the Sutton, Steele & Steele type and may be packed for sale to the steel foundries. By adding silica to the original charge or during the reducing operation aforesaid or by using pulverized garnet ore in which the binder contains silica a higher percentage ferrosilicon may be formed, and other substances, such as salt (NaCl) may be added to the charge to facilitate the fusing and to produce a purer alumina, but ordinarily this is not necessary as the garnet is in itself sufficiently rich in silica and iron for the complete success of the process as outlined. (1,192,394, July 25, 1916.)

Reduction of Sulphur from Sulphur Gases.—A process of recovering sulphur from sulphur gases in which gaseous or liquid reducing agents are used instead of

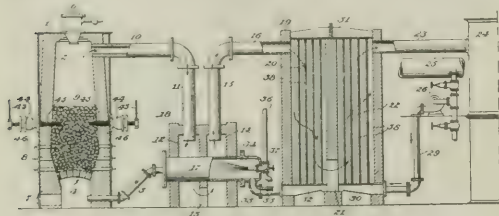


FIG. 2.—SULPHUR RECOVERY PROCESS

solid carbon as heretofore is patented by WILLIAM F. LAMOREAUX of Isabella, Tenn. In a previous patent, No. 1,140,310, May 18, 1915, of Lamoreaux and Renwick and application No. 6909, filed Feb. 9, 1915, a process was described in which sulphur-bearing gases are reduced by the action of incandescent coke or charcoal. The coke or charcoal is either heated by electricity or the gases are sufficiently preheated. In the present process sulphur-bearing gases are mixed with a determined amount of reducing agent such as carbon monoxide, hydrogen, hydrogen sulphide, or other vapors or atomized liquids obtained by volatilizing, atomizing, distilling or carbureting petroleum, bitumen, asphalt, etc. This mixture is then passed through a mass of incandescent carbon, which is heated by electricity. The carbon furnishes the heat necessary for reduction, but is not used up to any extent in the process. Apparatus in which the process may be carried out is illustrated in Fig. 2. Sulphur-bearing gases from a main 25 are drawn into pipe 29 by the fan 26 arranged as shown. The gases then pass to a recuperative chamber 19, in which they pass through pipes 38. The exit gases from the furnace pass in an opposite direction on the outside of pipes 38 in spaces 22, giving up some of their heat to the incoming gases. The incoming gases then pass through pipe 33 into mixing chamber 17, which is built in a brick enclosure 18, which is also a pre-heater. The reducing gas or liquid is blown in at 37. After being mixed the gases pass through pipe 3 into the furnace and up through coke, which is heated by electrodes 46. The sulphur is reduced and passes out with the other gases through the recuperative system and then to condenser 24, where the sulphur is recovered. (1,182,915, May 16, 1916.)

Apparatus for Burning Cement and Recovering the Dust.—Apparatus for burning cement and recovering the dust from the kiln gases is patented by HARRY J. SEAMAN of Catasauqua, Pa. Powdered coal is used. The kiln is of the usual construction, consisting of a lined cylindrical shell of steel, placed in position slightly inclined from the horizontal. The cement material is fed in at the upper end and the powdered coal nozzle and hot air nozzle which comprise the burner are at the other end. The coal drops from above into the hot air nozzle and is blown into the kiln where it burns. The gases from the kiln pass first to a compartment, designated as a separator. In the separator the gases pass through vertical steel tubes 10 to 15 in. in diameter and 10 to 20 ft. high. In the center of each tube conductors are placed, connected with a source of high tension current, thus forming an electrostatic separator. The gases give up some of their heat in the separator to air, surrounding the tubes and passing in an opposite direction. The particles of dust are driven outward toward the walls of the tube and adhere to them or fall below to a screw conveyor, which removes the dust from the several tubes to a common collecting chamber. From this separator the gases may go to a bag house, and from there to a "scrubber" or gas washer, in which the gas is passed through streams of falling water. The air which is passed through the separator, as mentioned above, to cool the gases passing through the tubes, becomes heated, and after passing through the separator is led under pressure to the hot air nozzle of the kiln burner, where it is used to force the powdered coal into the kiln and aid in its combustion. (1,185,136, May 30, 1916.)

Automatic Steel Hardening and Tempering Apparatus.—An apparatus for hardening and tempering thin, flat steel articles is patented by FRANKLIN D. FRISBEE and MALCOM H. BAKER of Boston, Mass., and assigned to the American Electric Process Steel Company of Boston, Mass. The process involves the use of several electromagnets and is substantially as follows: A number of the thin, flat articles to be treated are arranged in a row in a receptacle, at one end of which is an electromagnet, operating intermittently through a commutator. This magnet when energized draws one of the articles to a slot in the bottom of the receptacle, through which it drops when the current in the magnet is shut off by the commutator. The piece then falls between two heating heads, faced with platinum and also constituting electromagnets controlled by the commutator. When the piece is between the heads, the heads close and compress the piece, at the same time heat is supplied to the heads by gas burners. After being heated a sufficient length of time, the commutator releases the piece and it drops between two other water-cooled heads, faced with silver and operated in the same way, which cool the piece. The piece is then dropped to a tempering head, or dropped into a tempering bath, which completes the treatment. The operation is entirely automatic and the timing is arranged by suitably adjusting the commutator. (1,183,809, May 16, 1916.)

Suit Over Acid in River.—The Tennessee Power Co., Chattanooga, Tenn., has commenced suit against the Tennessee Copper Co., and the Ducktown Sulphur, Copper and Iron Works, to recover alleged damages to machinery amounting to \$25,000. The complainant alleges that sulphuric acid refuse which was emptied into the Ocoee River, from which the Power Company gets its water, caused some of its machinery to become pitted and ruined.

The Manufacture of Tannin Extracts and the Use of a New Evaporator

The manufacture of tannin and dyewood extracts from the natural raw materials, and the recovery of tannin extract from spent liquors in tanneries, etc., has assumed considerable importance in recent years. Immediately the industry assumed a position of importance it felt the need for chemical engineering control and attention in order both to improve the product and to increase the efficiency of production.

There are five important steps in producing extracts from the raw materials, which to the chemical engineer were obviously open to control, and investigation showed that on the method of carrying out these individual operations depended the question of producing an extract which embodied in the highest degree all the requirements of the tanners, or, on the other hand, one which could barely be termed a tannin extract.

The steps in question are as follows:

1. Suitable maceration of the bark or wood.
2. Correct extraction conditions.
3. Clarification of the extract solution.
4. Concentration of the extract (and in the case of some extracts).
5. Solidification of extract for shipment over long distances.

The first question (suitable preparation of bark, etc.), was chiefly the mechanical problem of preparing the material in such a form that with minimum power and handling, the material will be in the best condition for allowing the extraction liquor to remove its soluble tannin content. This has been accomplished without undue difficulty.

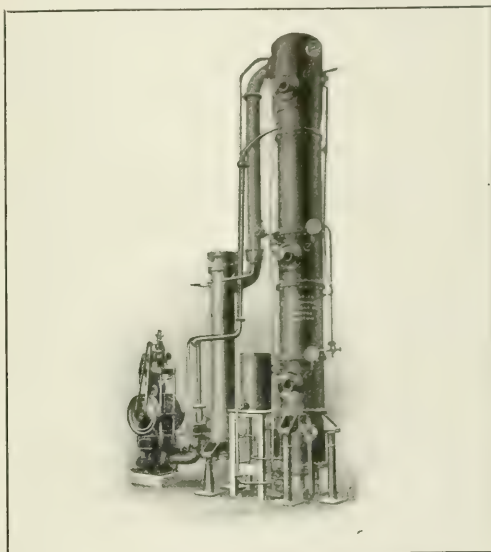
The second question was found to be of prime importance to the quality of the product, for by extracting for too long a period or under other variable conditions of temperature, circulation, etc., it was found that many substances soluble or partially soluble under these conditions were extracted with the tannin, and on concentration of the liquor a very impure extract contaminated with coloring matter, non-tannins and even organic acids were obtained. The production of a first-grade extract is now obtained by rigidly adhering to stipulated conditions of extraction.

The third operation, that of clarification of the extract liquor before evaporation, is, of course, patently necessary. To obtain an extract of maximum quality

it is obvious that foreign matter such as mud, sludge, chips, etc., be eliminated before the concentration begins. Conditions of clarification vary with the individual raw materials used, and consequently with the various plants in operation.

The fourth step in the process is perhaps the most important, for it is at this point that the grade or quality of extract is made or marred, supposing the preceding operations have been satisfactorily controlled.

Some liquids on exposure to heat deteriorate rapidly in color. For a long time it was supposed that the



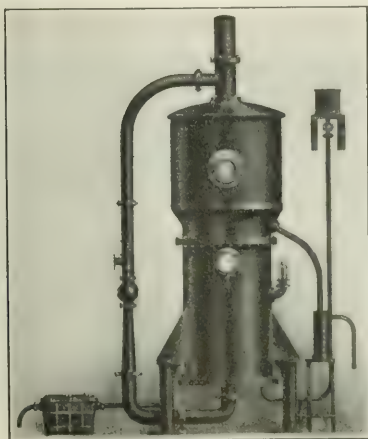
MULTIPLEX FILM EVAPORATOR, TRIPLE EFFECT

cause of this deterioration was entirely due to the temperature, so that many substances were concentrated in vacuum apparatus because the concentration could thus be carried out under greatly reduced heat. Experiments and experience brought out the fact that a sensitive material could stand concentration even at a high temperature if it could be done quickly, that is, if it were not exposed to high temperature for a long period of time.

This fact being established, the "multiplex" film evaporator was designed with a view to reducing the temperature by vacuum evaporation, and further to shortening the time that the liquid is in contact with the heating medium. Tannin and dyewood extracts are particularly sensitive as to the effect of overheating. As a consequence of the use of the "multiplex" triple-effect film evaporator, which is described in detail below, the liquid to be evaporated enters continuously in a very small amount and passes through the apparatus in about six minutes, leaving in its concentrated condition.

In cases where solid extract is desired, the concentrated extract from the "multiplex" at say 30 deg. Be., is drawn to a patented "finisher" single-effect pan of special design, or to a modified type of simplex rapid high concentrator. Solidification of the extract is an important economic feature where the product must be shipped a long distance.

Up to within the past few years concentration of tannin, glue, dyewood extracts, etc., has been carried out in only single effect, or at most, double-effect apparatus, in order to reduce the temperature effect. But



THE SIMPLEX RAPID EVAPORATING APPARATUS

even in these conditions the effect of time and mass of liquid was quite noticeable on the color of the product. By the use of a "multiplex" apparatus it is now possible to make use of triple-effect evaporation with its consequent economies of steam, water, power, etc., and obtain a product of prime quality without deterioration.

Even with a "multiplex" high temperatures cannot be totally avoided, but, in consequence of its design, the quantity of liquid contained in each separate "effect" is so small that the liquid remains in it only one to two minutes at most, and is then removed automatically to the next chamber at a lower temperature, and finally after only six minutes or so is drawn off completely concentrated. In the usual evaporator the liquid is not taken from the apparatus for several hours. Most liquids will stand the temperatures of evaporation without injury, their quality only being affected when these temperatures act on them in mass for a considerable time.

The standard type of condenser applied to "multiplex" condensation is such that all the condensed vapor is recovered in a pure state for re-use in extracting, a very important point. The amount of condensing water used is reduced as well as the first cost of the vacuum pump.

In view of the success of the "multiplex" evaporator, a new type has been designed for use in certain conditions where multiple effect plant is not required. The simplex rapid evaporator has proved that even at the temperature of 212 deg. Fahr., prevailing in it, very sensitive materials such as glue, colors, etc., show no perceptible deterioration owing to the short time occupied in evaporation—a few minutes only.

The simplex works at atmospheric pressure, requiring in consequence neither air pump nor condenser. It uses a very small quantity of steam owing to the patent economizer fitted to it; it holds only a small quantity of liquid; it is simple to attend, continuous working, and occupies very little space.

The photographs indicate one of the many uses to which these evaporators have been put in many countries and under varying conditions of operation. These evaporators are built by Messrs. Blair, Campbell & McLean, Ltd., Woodville Street, Govan, Glasgow, Scotland.

An Improved Centrifugal Pump

The development of the steam turbine and the high efficiency multi-stage centrifugal pump have gone hand in hand, but up to the present, it has been difficult to reconcile the speeds of the two machines so that each would work at its best efficiency.

It was necessary, heretofore, to reduce the speed of the turbine and sacrifice much of its efficiency or else speed up the pump with similar results. To overcome this difficulty the Cameron Steam Pump Works, 11 Broadway, New York, have designed and built a multi-stage centrifugal pump, known as the "BT" type.

Fig. 1 shows the construction of one of these three-stage pumps. With the ordinary impeller the diameter cannot be reduced sufficiently to get high speed without sacrificing vane length, and consequently, efficiency for a certain vane length is very necessary in order that the impeller may perform its function without excessive loss. Small external diameter and adequate vane length are obtained in this pump, by bringing the vanes well down into the impeller hub, at the same time so turning them that the incoming water is guided smoothly, and with little loss into the outer portion of the vanes where the velocity is generated that is finally converted into useful pressure by means of the external diffusion vane. Additional advantages in the small im-

PELLER are light weight and low fiber stresses in the material.

The casing is divided along the horizontal centerline. Both the suction and discharge connections are in the lower half of the casing. The upper half is readily removable, giving full access to the revolving element. There are suitable openings for draining the pump and for displacing the air when starting. Inlet and outlet nozzles can be arranged either on the same or opposite sides, an important advantage where pumps are installed in limited space.

The shaft is made of high-grade forged steel accurately machined and ground, and wherever it comes in contact with the fluid being pumped, it is thoroughly protected by bronze sleeves, which prevent the stuffing box packing from scoring the surface of the shaft.

Each impeller is cast solid in one piece and is of the enclosed type. Surrounding each impeller hub is a pair of rings, one stationary, attached to the casing, and one revolving, attached to the impeller. By the use of double rings instead of a single ring it is possible to restore the initial tightness of the joint between the low and high pressure sides of each stage without any fitting whatever, whereas a new single ring would have to be of special diameters, and then fitted to the impeller hub, or the casing to make a tight joint.

The diffusion ring surrounds the impeller at its periphery, although it is not in contact with it. It contains a series of openings, which receive the water from the impellers at high velocity and by means of gradually increasing area toward the periphery, reduce the velocity into pressure and enable it to advance to the entrance to the next impeller with much less loss of energy than would be the case if the high velocity of ejection were maintained.

To take care of thrust, which manifests itself in all multi-stage pumps, this pump is equipped with a simple internal hydraulic balancing device. This device consists of a revolving disc attached to the shaft at the inboard or high pressure end. Opposite this disc is a stationary drum of the same diameter. Water at high pressure connects with the space between the disc and the drum, causing the disc to react against the opposing thrust, neutralizing it and holding the rotor in proper relation to the casing. The slight leakage involved in this process is piped back to the suction.

On this pump, there are two ring-oiled bearings, self-aligning, one located on each side of the casing. The bearing bodies are horizontally split, with removable caps, and the bushings are also split and lined with high grade bearing metal. Bushings and bearing bodies

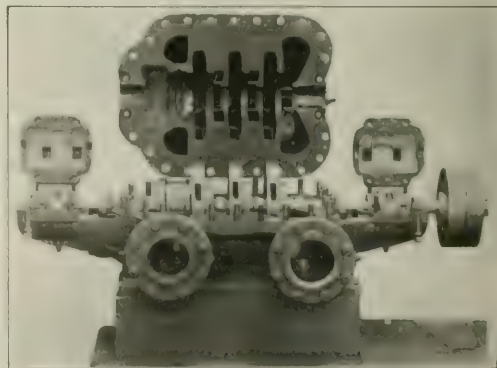


FIG. 1—THREE-STAGE TYPE "BT" BOILER FEED PUMP, SHOWING INTERNAL CONSTRUCTION

have a spherical fit, automatically maintaining the alignment of the shaft. The bearings are of ample proportions to prevent heating, and the oil chamber is of liberal capacity. The bearings are supported by strongly ribbed brackets, cast integral with the lower casing, thus counteracting any possible tendency toward vibration. These brackets are located sufficiently distant from the stuffing boxes to permit of adjustment of the glands. Felt washers are provided to prevent oil escaping from the bearings.

The stuffing boxes are deep and provided with water seals, consisting of a lantern gland in each box, connected to the water from the discharge side of the pump, through a concealed passage, so arranged that it can be readily cleaned. The stuffing box gland is fitted with swing bolts to give quick and easy access to the stuffing box. When the pump is direct-connected, it is supplied with a shaft coupling of the flexible type, to compensate for slight variation in alignment. The bedplate under the pump is of one piece box construction heavy enough to give a rigid support, and with cross ribs to prevent distortion.

Several of these pumps are now being built for the U. S. Government.

A Heat-Treating Plant Using Surface Combustion

A novel heat-treating plant is now being completed at the works of the Eddystone Ammunition Corporation, at Eddystone, Pa., by the Surface Combustion Co., of Long Island City, N. Y., to operate on artificial gas, on the surface-combustion principle. Surface combustion consists essentially in blowing a mixture of air and gas onto refractory material producing complete and flameless combustion on the surface of the refractory.

The theory of surface combustion and the conditions necessary for its actual operation were discussed in a paper at the International Engineering Congress in San Francisco in 1915 by C. E. Lucke, the inventor and original patentee of the process. (See this journal, Vol. XIII, p. 729, 1915.) See also Vol. XII, p. 325, 1914.) Considerable experimental work has been done by the Surface Combustion Company during the last two years on the commercial development of this process and a mixer for air and gas has been developed which maintains automatically constant mixture proportions of air and gas and eliminates all motors, blowers and air piping. This automatic mixer is a feature which has contributed largely to the successful development of the process. It is simple in design and con-

sists of two concentric pipes. Through the annular space between the two pipes the gas passes under pressure, while through the inner pipe air is sucked in in constant proportion. This constant proportion of air to gas is independent of the gas pressure. The principle is somewhat the same as that of a Bunsen burner.

The installation at Eddystone consists of three units of one hardening and one tempering furnace each, comprising a total of six furnaces. Two units are now in operation and the third is being completed. The furnaces are approximately 22 ft. long, 8 ft. wide, and 7 ft. high, outside dimensions, and were designed for a capacity of 5000 shells, 3 in. diameter and 8½ in. long per twenty hours per unit. The furnaces have cast-iron casings built up in small sections for easy replacement. They are lined with ordinary fire brick backed up with 1¼ in. of sil-o-cel brick.

In Fig. 1 is shown the charging end of a hardening furnace, back of which to the left can be seen the tempering furnace which goes with it. Fig. 2 shows the other end of this furnace with the oil quenching bath. Fig. 3 shows a longitudinal section and Fig. 4 a cross section of the furnace.

The shells are placed on a sliding tray in front of the small holes shown and at regular intervals are moved into the furnace by the piston of the air-pressure cylinder shown. As one row is charged the whole line of material on the hearth of the furnace is moved along and one row leaves the other end of the furnaces dropping through a chute down into the oil bath, shown in Figs. 2 and 3.

It was the intention to have the material taken from the oil bath by conveyors, and one is shown in Fig. 2, but at present this work is being done by manual labor, pending the design of a more successful conveying system.

The material is treated for one hour at 1550 deg. Fahr. in the hardening furnace, and after being quenched is dried on a drying table and is then charged into the tempering furnace which is similar to the hardening furnace. The material is drawn at 1150 deg. and afterwards air-cooled.

Running through each furnace are eight steel angles which act as troughs to carry the shells. A man stands in front of each furnace and feeds shells into the angle troughs. Every two minutes the pusher pushes the shells ahead the length of a shell. This causes eight shells to discharge into the oil-quenching bath located at the discharge end of the hardening furnaces, from which they are taken when sufficiently cool and fed into



FIG. 1—HARDENING FURNACES, CHARGING END

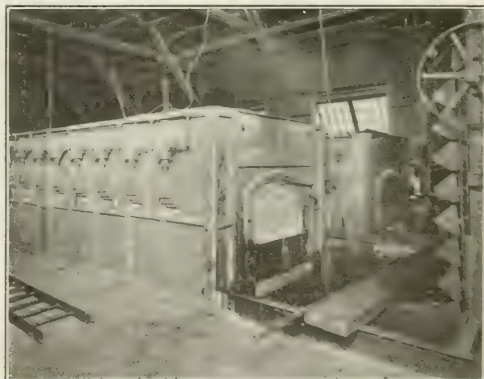


FIG. 2—REAR OR DISCHARGING END

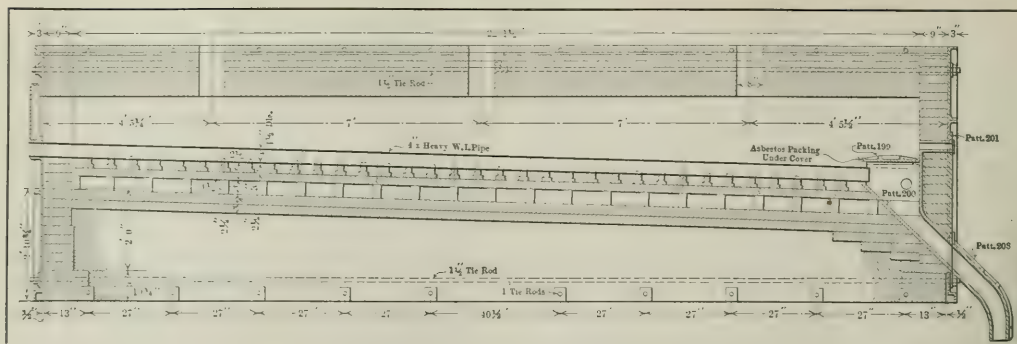


FIG. 3—LONGITUDINAL SECTION OF HARDENING FURNACE

the tempering furnaces in exactly the same manner. The furnace hearths are on a slight slope— $8\frac{1}{2}$ in. in the total length—and in the last two furnaces now being completed it has been decided to give the same slope to the roof of the furnace, thus making the hearth and roof parallel. In the other furnaces the roof is horizontal.

The gas is blown downwards as shown in Fig. 4, on to broken alundum where the combustion takes place. Carborundum has also been used for this purpose. The heat is radiated from this broken alundum up to the sides and top of the furnace and from there to the work. The design of the nozzle can be seen in Fig. 4. The end of the nozzle is surrounded with fire-resisting material to protect the nozzle from the heat and the flares on the nozzle just outside the furnace wall also help in cooling the nozzle.

The furnaces are as air-tight as possible. To prevent leakage in of cold air, which would produce an oxidizing effect and by its cooling action would lower the furnace efficiency, a slight furnace back pressure is maintained. As in all surface-combustion work the furnaces are so designed as to develop and utilize the maximum possible amount of radiant heat. The flues are arranged so as to distribute the hot gases uniformly and to release them at the lowest possible tempera-

ture. The hardening furnaces are equipped with 22 high-pressure burners, and the tempering furnaces with 18. All piping is laid in conduits having removable covers, thereby eliminating all overhead work. Each burner is fed by a $\frac{1}{2}$ -in. pipe from a 1-in. manifold.

Frequent flue gas analyses have shown that it is possible to have oxygen = 0.0, carbon monoxide = 0.0, and an average of 15.2 carbon dioxide. This shows that the heat may be generated with 100 per cent efficiency having no excess air or unburned gases. For the purpose of minimizing the scaling of the shells and to lengthen the life of the angle troughs, the furnace is operated with a slightly reducing atmosphere, carbon monoxide reading between 0.3 and 0.5. This is done to be on the safe side, as an oxidizing atmosphere would be very injurious in this operation.

All of the furnaces are controlled from a central control pulpit. Each furnace is controlled by a single valve which regulates the pressure supplied, and thus the temperature. The maximum pressure is 25 lb. and the minimum 5 lb. The average operating pressure is 15 lb.

Temperatures are taken by Brown electric recording pyrometers, one at each end of each furnace. All pyrometers are located in the central control pulpit. This allows one man to easily operate all of the furnaces. This feature has resulted in considerable saving of labor. As frequently as many as eight men have been necessary to care for burners and the control of temperatures on a similar number of furnaces of the same size, fired by oil. This feature also allows much more accurate and careful control as evidenced by the practically straight-line pyrometer charts which are secured daily.

There is also located in this pulpit the electric flasher, which times the charging operation. This machine flashes a red light in front of each furnace every two minutes, which flash is the signal for the men to operate the pushers.

Gas is furnished by the Philadelphia Suburban Gas & Electric Co. of Chester, Pa. Each unit consumes an average of 3300 cu. ft. per hour. The approximate average cost of the gas is 43 cents per 1000 cu. ft. It is furnished on a sliding-scale rate.

Several oil-fired furnaces operating on fuel oil costing 0.045 per gallon of practically the same size and doing the same work were in operation prior to the installation of these furnaces. One of these oil-fired furnaces was carefully tested, over a period of several days, the oil being measured in a calibrated tank. Subsequent tests of the gas-fired furnace showed a lower operating cost on this work.

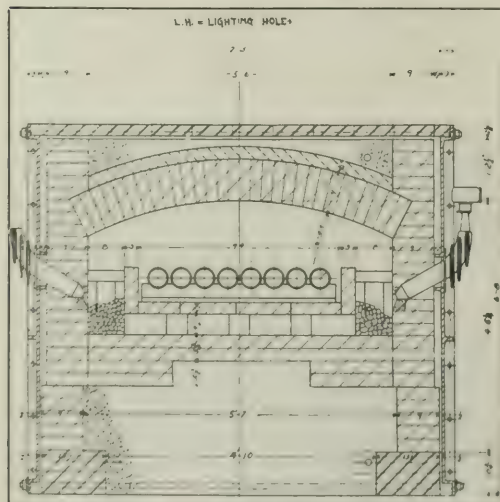


FIG. 4—CROSS-SECTION OF FURNACE

A New Important Installation of Pulverized Coal Under Stationary Boilers

When during the winter of 1912 the natural gas supply was limited in quantity and fuel oil hard to obtain in Kansas, the Missouri, Kansas & Texas Railroad Company officials decided to investigate other methods for generating steam in their boilers at the power house of their new shops at Parsons, Kan., where eight 250-hp. O'Brien boilers of the Heine water-tube type were installed with equipment for using only natural gas and oil as fuel. Some of the other fuels available in the district which would be within an economical range as to cost delivered at their plant were soft coals from the mineral mine in Kansas, McAlester and Lehigh mines in Oklahoma, and lignite from Texas, with the following government analysis as received:

Kind of Coal	Fixed Carbon	Volatile Matter	Ash	Moisture	B.t.u. Value
Mineral	45.22	26.39	20.38	8.01	10640
McAlester	47.07	32.37	14.29	6.27	11837
Lehigh	41.40	31.28	19.29	8.03	11200
Lignite	25.50	33.95	7.58	32.97	7548

The sulphur separately determined ranged from approximately 3 to 5 per cent in the various soft coals.

Owing to the ash and moisture content of these available fuels, it was determined by the Missouri, Kansas & Texas Railroad officials to investigate the method of using these fuels in a pulverized form, as they were aware of the fact pulverized bituminous coal had been in constant use in the cement industry, in a major portion of the plants throughout the country, and on many industrial furnaces for years, and the method of preparing this fuel eliminated almost all of the moisture before injection into the furnace, thereby obtaining the

highest possible B.t.u. value in the firebox from the fuel, instead of the loss that would obtain if used in the old way, by hand-firing or stokers, with fuel ordinarily received from the cars, as it was found cheaper to drive off this moisture in dryers designed for the purpose.

During this investigation the Missouri, Kansas & Texas Railroad officials found the Fuller Engineering Company of Allentown, Pa., had made an exhaustive study of fuels in pulverized form, designed and built coal-pulverizing plants throughout the world, and had already operated boilers with pulverized coal, and they were therefore engaged to design and construct what in their opinion would meet the requirements of these fuels.

After several conferences with Mr. Kellogg, superintendent of motive power of the Missouri, Kansas & Texas Railroad, the contract for this entire installation was signed and given to the Fuller Engineering Company of Allentown, Pa., on May 1, 1913, at Parsons, Kan., and all material and machinery was fabricated and delivered in Parsons in the fall of 1913, but in the meantime, owing to financial conditions, it was thought wise not to make the change at that time.

In the early part of 1916 orders were given to proceed with the work. The work was started in the spring, completed, and put into successful operation on Aug. 1, 1916.

Various tests were made with the different fuels mentioned above, and all of them were burned with entire success, showing no destructive effect on the fire-brick walls of the furnace, but giving a most effective distribution of the heat throughout the several passes of the boiler and exceptional heat absorptive effects throughout the heating surface of the boiler with low stack temperatures. No deposit of ash settled any-

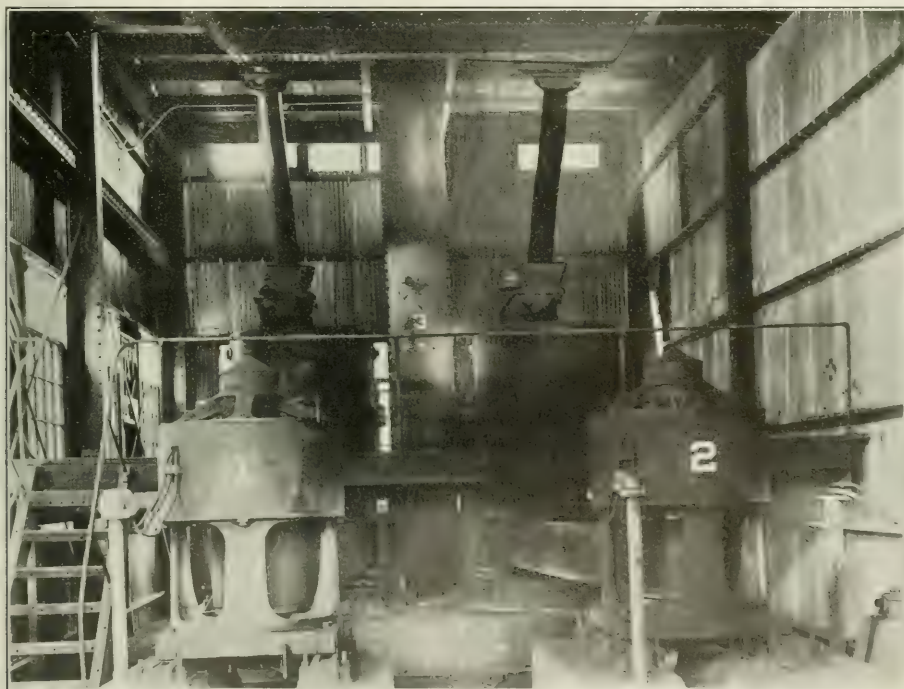


FIG. 1—42-IN. FULLER-LEHIGH PULVERIZER MILLS IN COAL PLANT AT PARSONS, KAN.

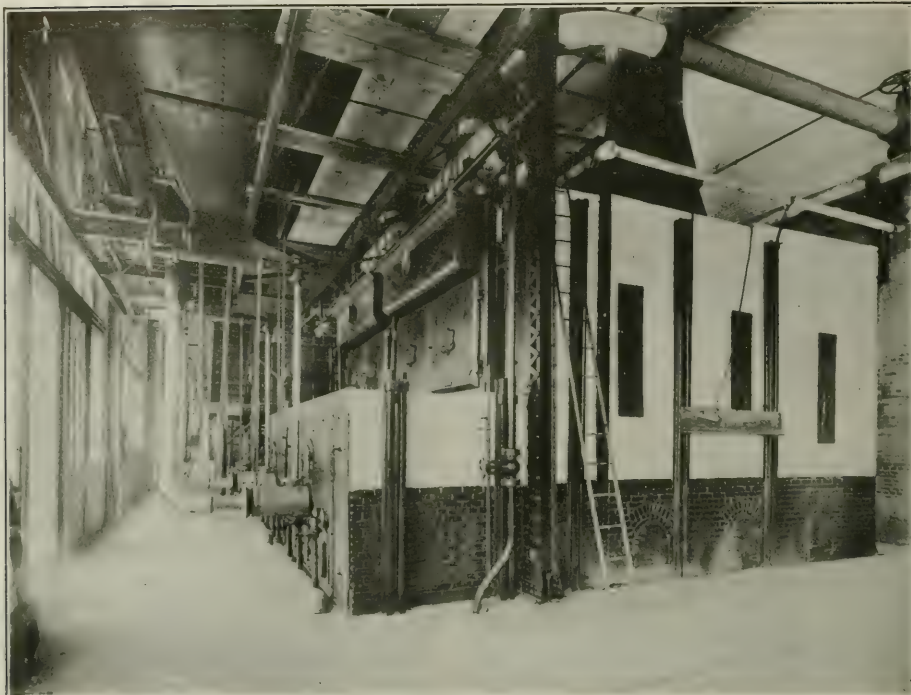


FIG. 2—VIEW OF O'BRIEN TYPE WATER TUBE BOILERS OPERATING ON PULVERIZED COAL AT PARSONS, KAN.

where in the boiler but what was readily dislodged with an ordinary air blast. The evaporation obtained with 16 per cent CO₂ in the stacks was 10.7 lb. of water per pound of combustibles from and at 212 deg.

As this is the first large installation of pulverized coal under a complete battery of boilers, the two accompanying illustrations of the plant should be of interest. Fig. 1 is a view of the 42-in. Fuller-Lehigh pulverizer mills, and Fig. 2 a view of the O'Brien type water-tube boilers operating on pulverized coal at Parsons, Kan.

Interesting Developments in Domestic Porcelain Ware Manufacture

Interesting developments are occurring in the chemical porcelain ware industry in this country. The industry is growing very rapidly, and the manufacturers who have undertaken to supply this country's demands for high-grade porcelain ware, which was mostly imported before the war, are certainly to be congratulated on their success. They deserve the encouragement and support of our chemists, chemical industries, and of the government.

Two large pieces have been recently made by the Guernsey Earthenware Company, Cambridge, Ohio, consisting of a retort and evaporating dish. These are shown in the accompanying illustration. The retort measures 34 in. high, 34 in. diameter, 20 in. across the top, 20 in. across the bottom, 16-in. opening at top, and has a capacity of 30 gal. The evaporating dish measures 11 in. high, 28 in. diameter, and has a capacity of 10 gal. These two pieces are claimed by the makers to be the largest pieces of chemical porcelain ware made in America up to the present time. The Guernsey factory now has a capacity of approximately 5000 pieces

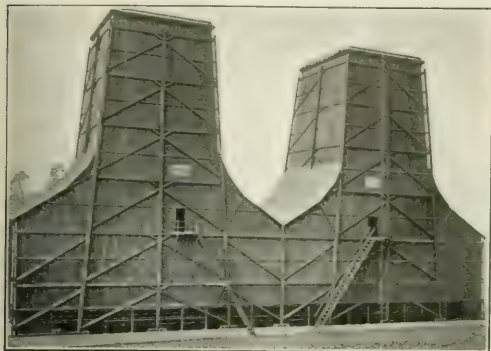
per day of chemical laboratory porcelain, and arrangements are being made to increase this to 10,000 pieces per day.



LARGE CHEMICAL PORCELAIN PIECES MADE IN AMERICA

A Large Cooling Tower

What is believed to be the largest natural draft cooling tower so far built has recently been completed at the Anderson, Ind., plant of the American Steel & Wire Co. This tower is of the Wheeler-Balcke type built by the Wheeler Condenser & Engineering Co., of Carteret,



LARGE COOLING TOWER AT AMERICAN STEEL & WIRE CO.

N. J. The tower is approximately 150 ft. long, 50 ft. wide and 75 ft. high and has a yellow pine frame with cypress sheathing and filling. The tower, as shown in the accompanying photograph, has two chimneys which rise above the cooling stacks and create the air circulation by natural draft. The capacity of the tower is 7300 gal. a minute cooled from 115 to 85 deg.

Personal

Prof. Charles H. Herty, Dr. W. R. Whitney, Dr. L. H. Baekeland and Prof. Warren K. Lewis have been appointed by the American Chemical Society to co-operate with the committee of the National Academy of Sciences on the nitrate question.

Mr. A. C. Lyon is in charge of the newly formed General Testing Laboratory at Kansas City, Mo., organized to conduct chemical, physical testing and metallurgical work. Mr. Lyon was formerly for a long time chief chemist and vice-president of the Kansas City Testing Laboratory, and previous to that time he was with the Carnegie Steel Co. The offices and laboratory of the new company are at 1122 Grand Avenue, Kansas City, Mo.

Mr. William D. Manchester of Rocky Hill, Conn., has been appointed superintendent of the crushing department of the Chile Exploration Co., Chuquicamata, Chile.

Mr. C. R. Pfafenbach has resigned as chief chemist of the Simonds Manufacturing Company, Lockport, N. Y., to take charge of the chemical and metallurgical work of the Covert Motor Vehicle Company of Lockport, N. Y.

Mr. J. B. Risque has resigned as manager of the Tennessee Copper Co., and Mr. N. H. Emmons, 2nd, has been appointed manager to succeed him.

Mr. C. B. Semple, formerly manager of the Chicago office of the Duplex Metals Co., and more recently with the Hazard Manufacturing Company, has been appointed manager of the copper-clad steel department in the Chicago office of the Steel Sales Corporation.

Mr. Thomas M. Skinner, Jr., has resigned as superintendent of the Mid-Continent Chemical Co., of Sand Springs, Okla., to accept the position of assistant manager of the Potash Products Co., Alliance, Neb.

Mr. Ivan P. Tashof has resigned as instructor in mining and metallurgy at the College of Mines and Metallurgy of the University of Kentucky, and will enter the practice of patent law with Messrs. Byrnes, Townsend and Brickenstein, of Washington, D. C.

Mr. J. A. Wilkinson has been elected president of the Chemical, Metallurgical and Mining Society of South Africa.

Mr. G. H. Wohlhaupter, formerly connected with the Utah Copper Co., is now conducting flotation experiments for the Stimpson Equipment Co., of Salt Lake City.

Industrial Notes

New Electric Heater.—Messrs. Woldenburg & Schaar, Chicago, Ill., have placed on the market a new electric heater for use in the laboratory in heating flasks, beakers and general apparatus. The heater is designed for practically all purposes for which Bunsen burners and hot plates are used. The top of the heater will accommodate a 1-liter flask. For use as a hot plate a metal disc is supplied which fits on the top. For heating test tubes a perforated cylinder is supplied.

New Borax Fields in Chile.—According to a report from the commercial attaché at Santiago, Chile, new fields of calcium borate are said to have been found near Iquique, and that 150 claims, or 18,750 acres, have been solicited. Average values of 15, 20, 30, 40 and 60 per cent of borax are given.

Fuel Testing.—Messrs. Elmer & Amend, New York City, have issued an interesting and valuable booklet on "Fuel Testing Apparatus." The booklet discusses coal-testing methods, the sampling of coal, and gives a detailed outline of procedure for determining heat of combustion of fuels in the Emerson calorimeter. The method of standardizing a calorimeter is also given, together with descriptions of the Parr calorimeter and accessory apparatus required for fuel testing, such as electric furnaces, electric ovens, pyrometers, grinding machines, etc.

The Crocker-Wheeler Company, Ampere, N. J., announces that its San Francisco district office, of which Mr. W. K. Brown is district manager, has been removed from the Crossley Building, 619 Mission Street, to the ground floor of 37 New Montgomery Street. A large assortment of motors, generators and transformers will be carried in stock for the convenience of buyers of electrical equipment on the Pacific Coast.

Aluminium and Bauxite In 1915.—The production of bauxite in the United States in 1915, according to a recent Geological Survey report, was 297,041 long tons—an increase of 35 per cent over 1914. This is an abnormal increase and is accounted for by the large increase in the manufacture of aluminium. The figures for the consumption of aluminium in 1915 are given as 99,806,000 lb., over 20,000,000 lb. more than consumed in 1914. The Aluminium Co. of America greatly extended its operations during the year and is continuing to expand and increase its production so as to be able to supply the domestic demand, even with all imports cut off.

Large Increase in Lime Used by Chemical Works.—The amount of lime used in 1915 by chemical works increased 34 per cent over 1914, according to figures

gathered by the U. S. Geological Survey. These figures are interesting, as they show the greatly increased activities of our chemical industries. The lime for chemical works represented nearly one-seventh of the total quantity used in 1915. This does not include lime used in smelters, alkali works, glass works, and many other industries. The amount sold to chemical works in 1915 was reported as 492,870 short tons.

Grinding Machinery.—The Colorado Iron Works Co., Denver, Colo., has issued pamphlet No. 31, describing ball and tube mills and grinding pans. The pamphlet is nicely illustrated and contains considerable reading matter of great technical value, including tables of slime density relations.

Fuel in Russia.—The general opinion of Russia is that it is a country very much backward industrially, and from other points of view. It is well known, however, that enormous natural resources are contained in the country. Since the war started Russia has had to rely on its own resources. According to the Chemical Trade Journal and Chemical Engineer the condition as to fuel is, however, quite serious.

That which in normal times, and more than ever now, renders difficult the distribution of fuel in Russia is the absence of means of communication, and, above all, the lack of rolling stock. It is to this lack that Russia owes her economic torpor, and her finding herself at the present time, from the point of view of the supply of fuel, in a somewhat distressing condition. As on the other hand very severe restrictions on the cutting down of forests have been prescribed, the employment of wood as a substitute for coal has been rendered very difficult.

The situation has, however, been relieved by the utilization of the petroleum with which the country is so abundantly provided, and particularly by the use of the residues from distillation. From January to September, 1915, the shipments of naphtha and its derivatives by the Volga exceeded by 33 per cent those of 1914. This supplementary use of oil may be reckoned as 80 million poods, which, on a colorific value of 10,000 calories, would correspond to about two million tons of coal.

Until about 1910 Russia restricted herself to the production of coke without recovering the by-products, valuable for so many purposes. At the end of 1913 the number of recovery coke ovens in the whole of Russia was 848. Their output (for the whole of 1913, for six months only of 1914 and 1915) was as follows:

	1913	In Poods 1914	1915
Coke	79,550,000		
Tar	2,410,300	1,439,000	1,656,000
Ammoniacal liquor (25%)	1,014,000	558,000	628,000

The production of coke in the Donetz region was 278 million poods in 1914 and 251 millions in 1915. It will be seen that two-thirds of the coal are still carbonized without the recovery of the by-products.

Russia is the most important producer of oil in Europe, and the second in the world, the United States being the first. The principal center is situated in the Baku region. The Russian production has not, however, in the last ten years had the intensive development that has characterized the American and Roumanian production. While the world's output has increased from 29,775,000 tons in 1906 to 57,920,000 tons in 1914, the Russian production has only passed from 8,168,000 to 9,173,000 tons in the same space of time. There was a slight increase for 1915, 13 million poods more than in 1914, the yield being 9,348,000 tons.

Book Review

Niagara, Queen of Wonders. By Edward Theodore Williams. 188 pages, profusely illustrated. Price, \$2.00. Boston: Chapple Publishing Co., Ltd.

This is a most interesting book, a graphic history of the development of Niagara in three centuries. The author is the president of the Niagara Frontier Historical Society and has been for eleven years managing editor of the *Niagara Falls Journal*, and for five years industrial agent of Niagara, N. Y.

The author first takes up the early history of the Niagara frontier, beginning with the struggle between the French and English for control, the occupation of Fort Niagara by the United States, and the war of 1812. A letter by Peter Kalm, dated Sept. 2, 1750, reprinted as being the first account of the Falls in English, is a charming human document.

The author next discusses the "free Niagara" project. Up until 1885 the shore of the Falls was occupied by so-called squatting interests who taxed visitors to the limit. In 1885 the New York legislature passed a bill appropriating money to acquire necessary land including islands near the Falls to make a public park and thus make the Falls free to all. The bill was passed on recommendations of a commission.

The first real power development, the hydraulic canal, was commenced by Horace P. Day in 1853 and finished in 1861. He spent a lot of money and was not successful. It was not until 1875 that it was successfully used. The canal was purchased by Jacob F. Schoellkopf of Buffalo, in 1877, and the original Hydraulic Power & Mfg. Co. formed in 1878. Three generations of the family have been in control ever since. Dynamos were installed by this company in 1881. In 1895 they commenced power station No. 2 which has since been superseded by station No. 3, one of the finest in the world. Most of this company's power is used in electrochemical and electrometallurgical work.

The development of the Niagara Falls Power co. is next taken up, beginning with the granting of the charter by the N. Y. legislature in 1886, which gave them the right to develop 120,000 hp. from one tunnel and 100,000 hp. from another. Owing the federal restrictions the second tunnel was never constructed. The first power was delivered by this company on Aug. 26, 1895, to the Pittsburgh Reduction Co., now the Aluminum Co. of America, which company now uses 75,000 hp. The allied company, the Canadian Niagara Power Co., was also formed at this time. At present the American company furnishes 106,000 hp. and the Canadian company 112,500 hp.

Details of the growth of the City of Niagara Falls, N. Y., are next given, with a list of the important plants. The great question of diversion is taken up, including a discussion of agitation against further development, the findings of the International Waterways Commission, the passage of the Burton Act in 1906, limiting diversion of water on the American side, and Secretary of War Taft's opinion after his hearing at Niagara in 1907. The Burton law requested the President to open negotiations with Great Britain and a treaty was effected in 1910, for five years, terminable on 12 months' notice.

The author is strongly in favor of further diversions and many data are given to show that scenic grandeur will not be destroyed. A discussion of Federal vs. State control is also included.

Taken in the whole, the book is very suggestive reading and contains much that will be new even to those who have been fond of Niagara and Niagara history for years.

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The Meaning of Chemical Convocation Week

John Muir, in his Mountains of California, says of the wild sheep of the Sierra Nevada that "each one of the flock, while following the guidance of the most experienced, yet climbs with intelligent independence as a perfect individual. The domestic sheep is only a fraction of an animal, a whole flock being required to form an individual, just as numerous flowerets are required to make one complete sunflower." This expresses clearly the difference between the pioneer and the descendant.

But the necessity for pioneer work never ceases. It only shifts with the progress of civilization to new sets of men, as new fundamental problems develop. The prospector and the mining engineer are the first pioneers of civilization. The civil engineer, building roads and bridges, follows, to be followed again by mechanical and electrical engineers and so on. In this procession of engineers the chemical engineer comes last, because his work presupposes the existence of a civilization so highly developed that waste goes on to such an extent and in so many different lines as to cry out loudly for the necessity of a complete change. Here the work of the chemical engineer sets in. It is his task to change waste into new sources of production. He is a true pioneer and a true creator. Now the psychological moment has come for the chemical engineer to take his proper place in this country. The chemical engineer is to be the pioneer of the next generation.

During the past week we have had in New York City the biggest gathering of chemists this country has ever seen with the only exception of the International Congress of Applied Chemistry in 1912. During the past week it was a purely national affair, but it was truly national. The exposition and the conventions of the societies emphasized the nation-wide scope of the problems before the chemist at this time. And on the whole it was a glorious week. True, not everything was perfect. There was too much scattering of effort, with meetings going on, often simultaneously, at Columbia University, at the Astor Hotel, at the Chemists' Club, and at the Grand Central Palace. And the very bigness of some of the functions was an obstacle, as in the case of the smoker; in an audience of over 800 men in an immense gilded ballroom the true atmosphere of an old-fashioned smoker cannot develop. But it was a great week, nevertheless, and it proved that the American chemists are fully alive to the tasks set to them, while even the general public is beginning to realize the scope of chemistry as evidenced by the unusual publicity given to the proceedings in the daily papers. We need only remember how the daily press treated the Con-

gress of 1912, in order to realize the progress which has been made in the last few years.

And it was a truly representative and inspiring gathering. The leaders of the profession were there, such as Acheson and Baekeland, to mention just the A and B in the A, B, C of the big leaders of American chemistry. And the rank and file was there. We cannot all be leaders and founders of new industries. But we can all stand together and work together. And the country needs just as much the honest work of the humblest worker of the rank and file as it needs the genius of the leader.

In this respect Chemical Convocation Week will long be remembered as it proved conclusively that the American chemists form, as Dr. Nichols once expressed it, a true democracy. In spite of the scattering of the sessions all over the city, it was a true coming together of American chemists in spirit and resolute desire to help each other. This is the spirit that leads to success. And in the expression of this spirit we see the final meaning of Chemical Convocation Week.

Pittsburgh in Iron and Steel

The annual statistical report of the American Iron and Steel Institute, just issued, gives a little statistical information as to iron and steel production in 1915 not included in the bulletins that have been issued from time to time. Of particular interest is a table of production in Allegheny County, of which Pittsburgh is the center. Unfortunately the production of Allegheny County is not the production of what is strictly entitled to be called the Pittsburgh district, for some fifteen years ago the district outgrew the limitations of the county line. First it extended up the Monongahela River beyond the county line and afterwards it extended down the Ohio River in similar fashion.

Even the statistics of Allegheny County, however, show what a remarkable district is Pittsburgh in the manufacture of iron and steel. Production in 1915 in gross tons was as follows:

Pig iron	5,970,407
Bessemer steel	1,351,416
Open-hearth steel	6,367,036
All other steel	28,928
Total steel ingots and castings	7,747,380
Rolled iron and steel	5,733,550

Outside the county, but still in the immediate Pittsburgh district, are two blast furnaces at Monessen, two at Donora, four at Woodlawn and one at Midland. As 1915 was not a year of full production, the actual capacity of the Pittsburgh district may be taken as in excess of 8,000,000 tons of pig iron annually.

The great bulk of the pig iron production of Allegheny County is basic iron. It will be observed that the production of Bessemer steel was but 17 per cent of the total steel production, hence the production of Bessemer pig iron was relatively small. There is very little foundry iron produced in the county, there being but one merchant furnace. It is curious that this furnace was the first to be built in the county, except for an unsuccessful furnace in the eighteenth century. Other merchant furnaces were built subsequently, but

have been absorbed by steel interests. A considerable quantity of spiegeleisen and ferromanganese is produced. Even with these complications, however, the consumption of ore and limestone in the manufacture of the pig iron is of considerable interest. All the ore is Lake Superior, of course, and as it is transported a thousand miles from mine to furnace it must be of good quality to make it worth while. With very few exceptions the furnaces are modern and of large capacity. The average consumption per ton of pig iron was as follows, compared with the average of the whole country:

	Allegheny County	United States
Iron ore	1.830	1.843
Mill cinder, scale, etc.	0.090	0.149
Total	1.920	1.992
Limestone	0.514	0.494

The smaller consumption of iron ore in Allegheny County per ton of pig iron produced is to be expected, as the average of the country at large is pulled up by the relatively low-grade ores consumed in some districts, particularly in the South. The higher limestone consumption would hardly be expected as an attendant phenomenon, and needs to be explained on special grounds.

Allegheny County is practically self-contained as to its steel industry. Very little steel-making iron is shipped into it, but considerable tonnages of old material are shipped into it, and the various shops produce a great deal of industrial scrap, all this material finding its way into the open-hearth furnaces. The production of rolled iron and steel is nevertheless sensibly less than the production of pig iron, despite the fact that a small portion of the rolled material is iron, made directly from scrap, and thus Allegheny County shows, as does the whole country that after all rolled steel is simply produced from pig iron. The scrap produced by the steel works, and charged into the open-hearth furnaces, merely represents a detail in steel production. The statistics of the production of ingots, therefore, are useful chiefly as an index to steel works capacity. The ingot production diverges widely from the quantity of commercial steel produced.

Æsop at the Grand Central Palace

Enjoying a holiday through being on sympathetic strike, Æsop wisely decided to spend it at the National Exposition of Chemical Industries. After gravely and philosophically contemplating innumerable booths decorated with fabrics of many colors or exhibiting vials of priceless crystals and aromatic liquids, he paused in front of an automobile placarded and beribboned like a bridal car, above which hung the legend: "Niagara Made Detroit Possible." He combed his whiskers meditatively with his knotted fingers and was heard to mutter:

"A dog, bearing in his mouth a piece of meat that he had stolen, was crossing a smooth stream by means of a plank. Looking in, he saw what he took to be another dog carrying another piece of meat. Snapping greedily to get this as well, he let go the meat that he had, and lost it in the stream."

The Growing Wealth of the United States

There has hitherto been danger of overestimating the increase in the wealth of the United States arising from the large favorable trade balances, but the successive large increases in the balances in recent months indicate that all overestimates will be made good.

In making computations there has been great liability to err by neglecting certain vital factors. Commonly the assumption has been made that the merchandise balances in the past have sufficed approximately to equalize with the unseen balance against us, and that is greatly to be doubted. Sometimes also there is a disposition to assume that since the war started the unseen balance against us has been smaller than formerly. That also is to be doubted.

It was in 1898 that the first really large favorable balance developed. The average balances in eight-year periods have been as follows:

1898-1905.....	\$509,339,793
1906-1913.....	500,393,290

It seems altogether unreasonable to assume that the majority of items in the unseen and unfavorable balance did not increase during the period covered by the above presentation, and yet the favorable merchandise balance did not increase, but decreased slightly. There was an increase of 64 per cent in our imports, hence freights paid on imports to foreign vessel owners certainly increased, and that is an important item in the unseen balance. Expenditures abroad of American tourists undoubtedly increased. With the large increase in immigration remittances abroad of foreign born residents presumably increased. Foreign holdings of American securities increased, hence the payment of interest and dividends to foreign holders increased. There was no important change in the gold movement.

There is every reason to believe, therefore, that the unseen balance increased, and with no help by an increased merchandise balance the liquidation must have occurred by American securities being sent abroad. We ran into debt faster in the eight years ended 1913 than in the eight years ended 1905.

In 1914 the merchandise trade was very unfavorable, while in 1915 there was a record balance in our favor, the balances being as follows:

1914.....	\$324,348,049
1915.....	1,768,883,677
Total.....	\$2,093,231,726

At the end of 1914 we owed money, which was paid in 1915. If the unseen balance necessary to be liquidated was \$500,000,000 a year we gained in capital in the two years by a trifle more than \$1,000,000,000. In all probability that is an excessive estimate, as the imports were large and freights paid to foreign vessel owners were very high. Our net receipts of gold in the two years were \$585,757,087. Apparently, then, there was little left, up to Jan. 1, 1916, to be liquidated by our making loans abroad or by our buying back our securities.

One will probably be not far wrong in assuming that

our loans to foreign nations and our purchases of our own securities are all to be set against favorable merchandise trade balances that have accrued since the first of this year. The loans total fully \$1,250,000,000, the largest being the \$500,000,000 joint Anglo-French loan of last year and the \$250,000,000 British loan recently, the latter being based upon American securities gathered in London as collateral. We are not altogether clear as to the bearing of the reports made by Mr. L. F. Loree as to the reduction in our railway securities held abroad, and in any event there is nothing definite as to the reduction in securities other than railroad. The total reduction may easily be, to use round figures, \$1,750,000,000, making with the direct loans \$3,000,000,000 altogether. This year's trade balances have been:

January to June	\$1,198,576,369
July	262,749,062
August	310,752,609
Eight months	\$1,772,078,040

The net gold imports in the same time have been in the neighborhood of \$250,000,000, leaving \$1,500,000,000 of the merchandise balance to be settled otherwise, but if we have loaned money and purchased our securities to the extent of \$3,000,000,000 there would appear to be a foreign credit of one-half this amount.

It will be understood, of course, that we do not regard these figures as precisely accurate, and at minor points the reasoning may be subject to some question, but on the whole it seems clearly evident that the foreigners have taken excellent care of their finances and that to square ourselves we must have large favorable merchandise trade balances in the future. The August balance was at the rate of \$3,700,000,000 a year. Roughly speaking, the foreigners have apparently taken care of five months' of trade balances, beginning Sept. 1. It is a matter of common trade knowledge that large payments have been made on munition contracts before the manufacture began, and that payments are made on delivery at seaboard, before the merchandise is actually loaded on vessel.

Assuming a continuance of these trade balances for some time to come, the country will have become rich by the return of a large volume of American securities, and by the loaning of a great deal of money abroad. By reason of these changes the unseen balance against us will be greatly reduced for the future, and we may even be placed in the position England has long enjoyed, whereby revenue from investments flows into the country. If we had an adequate American merchant marine we should earn money by that means also. A condition may be conceived, therefore, of our being able in future to import a larger value of merchandise than we export. If a country can really afford to do this, and the imports and exports respectively are of the right character, the condition is a highly satisfactory one. The prime requisite, in any event, is that the tariff be so regulated that both our import and our export trade is made conducive to the prosperity of the people as manufacturers and traders. There is a grand opportunity to be embraced.

Readers' Views and Comments

Why Boiler Tubes Need Not Be Subject to Coarsening

To the Editor of Metallurgical & Chemical Engineering

SIR:—In an important paper¹ on the coarsening of low-carbon boiler-tube steels, White and Wood infer that these are necessarily in danger of bagging or failure (page 26 of preprint). This they infer from the fact that their results, if extrapolated, indicate that the first stages of coarsening will occur in such steel on exposure for nearly three years to a temperature as low as 400 deg. C., provided that it has first undergone the special form of deformation used in their experiments. This was to indent it with a 5-mm. ball under a load of 800 kg. They truly hold that such tubes may undergo some degree of plastic deformation after annealing and before service, and further that local overheating may be brought about in them in service by the presence of even a thin layer of boiler scale.

Were it true that the tendency to coarsen is as strong after very slight plastic deformation as it is after the severe deformation which these investigators use, their fears would be quite justified. In fact this tendency increases directly with the degree of deformation which the metal has undergone, so that the slighter the deformation has been, the longer is the time and the higher is the temperature needed to cause coarsening. It is this that explains the relative rarity of coarsening on slight heating after deformation. Thus while it is true that boiler tubes may well undergo some deformation between annealing and service, it ought to be possible to restrict that deformation to a degree which is insignificant compared with that which Messrs. White and Wood use, and thus to increase the time and temperature needed to cause coarsening too far beyond that to be expected in good boiler practice, and thus in fine to remove this danger.

The severe deformation which the very ends of the tubes undergo when expanded into place need not be considered here, because these ends are well protected from the heat.

HENRY M. HOWE.

Bedford Hills, N. Y.

Electrolytic Formation of Perchlorate

To the Editor of Metallurgical & Chemical Engineering

SIR:—In the discussion of a recent paper before the American Electrochemical Society on the "Electrolytic Formation of Perchlorate" occur the following passages:

PRESIDENT ADDICKS: The experiments on the oxidizing effect of oxygen activated by ultra-violet light remind me of work I was interested in several years ago in connection with the recovery of selenium from flue dust. The selenium was leached out using KClO₄ as an oxidizing agent in shallow porcelain pans in the open air. It was found that the yield was much greater on sunny days than on cloudy ones.

C. W. BENNETT (Communicated): We have been unable to bring about the breaking down of potassium chlorate with ultra-violet light. It is probable that the increased efficiency on sunny days is brought about through oxidation of the metal by activated oxygen, the potential of which is sufficiently raised by the presence of the chlorate.

It was a pity to drive Mr. Bennett to looking for an explanation of a phenomenon which was incorrectly re-

ported. The reagent used was a mixture of KClO₄ and HCl, the selenium being brought into solution as chloride.

DONALD M. LIDDELL.

7 Wall Street, New York City.

Coming Meetings and Events

American Gas Institute, Chicago, Oct. 17-20.

American Mining Congress, Chicago, Nov. 13-18.

American Society of Mechanical Engineers, New York, Dec. 5-8.

American Institute of Chemical Engineers, New York, Jan. 10-13, 1917.

The Western Metallurgical Field

The Vindicator Flotation Test Plant

Fig. 1 is the flow sheet of the Vindicator Flotation Test Plant, the nature of which is clearly indicated in the drawing. The new features of interest are as follows: The ore is washed before milling and the waste is sorted out; the ball-mills are placed in series instead of in parallel, as is the usual practice; the tailings are tested on a Wilfley table, which acts as a pilot table and indicates the correct working of the process. This table is closely watched, and if any concentrates are observed on it the process is not working at its highest efficiency. The trouble is then looked up and remedied.

Another striking feature is the handling of the tailings. These are pumped over a mountain. The length of the tailing pipe is 8000 ft. and the elevation, including the friction, is 408 ft.

Ball-Mills at the Hollinger Consolidated

The general tendency in the past few years in the Porcupine district has been the replacing of the stamps by ball-mills. The Dome company gradually increased its output by replacing the stamps by ball-mills. Now the Hollinger Consolidated has added a new ball-mill to their plant, enabling them to treat the full estimated tonnage of 1900 tons per day. Improvements have also been made in the cyaniding department which materially increase the efficiency, and the new electric substation which has been under construction is rapidly nearing its completion.

Mills

The general trend of the West is to increase the output of the mills. The Pacific Mine, Utah, is constructing a new mill on Dutchman Flat to handle its sulphide ores. The mainstay of the mine is its copper sulphide, which yields a concentrate running from \$50 to \$60 per ton. Some lead-silver ores are also available. The mill under construction has a daily capacity of 65 tons. As the ratio of concentration is 1 to 4, the daily output of concentrates will be between 15 and 16 tons. The machinery is practically all on the ground and the mill is expected to be in operation by Nov. 1. The mill will be so constructed as to permit the addition of new units as the output increases.

Within a short time the Big Four Exploration Co.'s mill situated at Park City, Utah, will increase its output from 400 tons daily to 1000 tons of tailings. This is accomplished by modifying the feeder system. In approximately a month's time the new flotation plant

¹Re-crystallization as a Factor in the Failure of Boiler Tubes, by A. E. White and H. E. Wood, June, 1916, meeting of the American Society for Testing Materials.

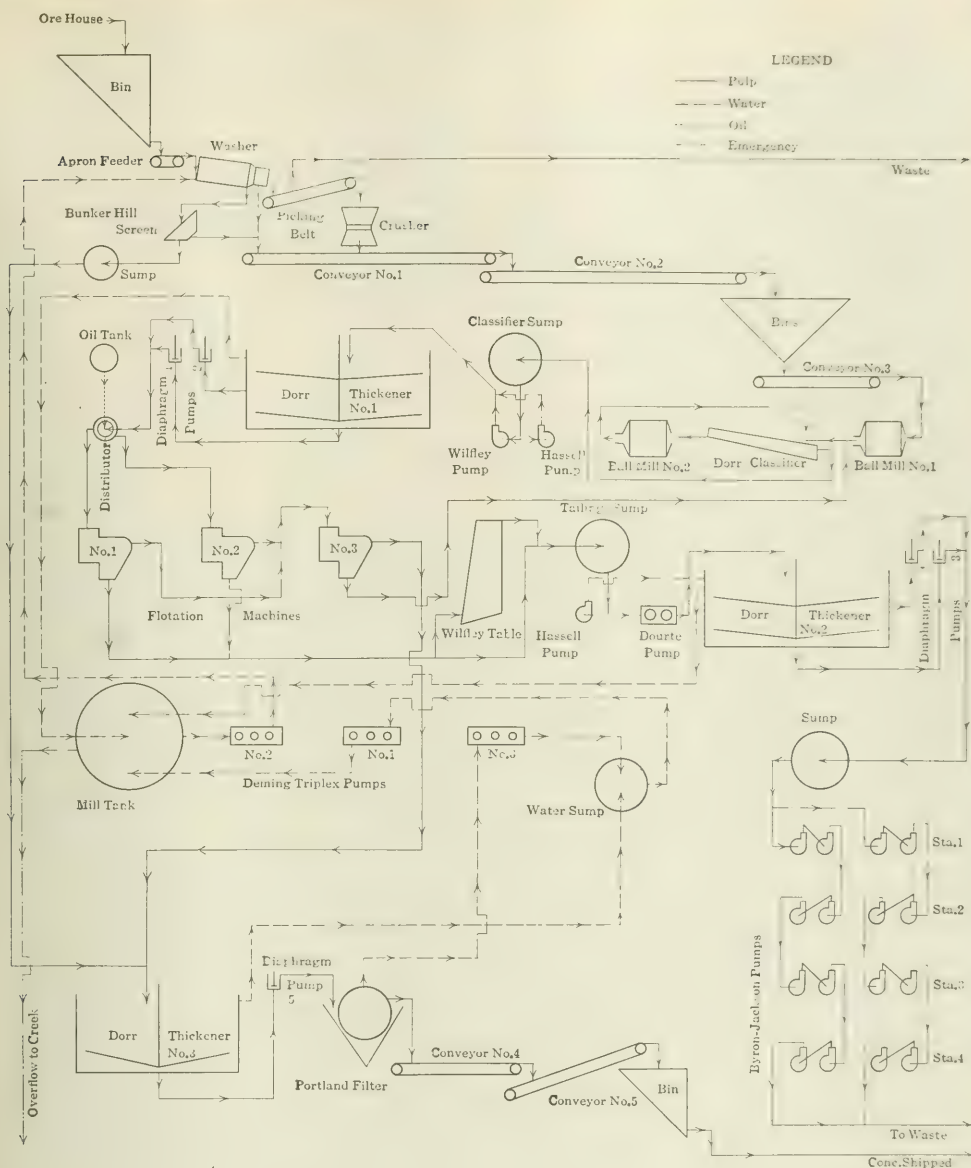


FIG. 1—FLOW SHEET OF THE VINDICATOR FLOTATION TEST PLANT

will also be in operation, which will materially increase the savings on the slimes material. When working at full capacity the mill will turn out 1500 tons of lead-iron concentrates and zinc concentrates per month.

Relief of the Smelter Congestion

For the past few months the smelters of the Salt Lake valley have been congested with ore, due to the unusual activity in mining brought about by the high price of silver, lead and copper. It was impossible for the smelters to handle all the ore shipped them, and material has been refused which at other times

was gladly accepted. The American Smelting & Refining Co. has solved the problem by increasing the capacity of its Garfield and its Murray plants.

The plant at Garfield will be enlarged in such a manner as to double its capacity within the next half-year. The smelter will then be able to turn out 800 tons of copper a day, which is equivalent to 48,000,000 lb. per month. The plans have been completed and some of the structural steel is already on hand.

The demand for an increased capacity of the Murray plant was even more stringent than for the Garfield plant. This was due to the insistent demands of the small producers, scattered all through the valley,

that their ore be taken care of. The Murray plant handles lead-silver ores, and steps have been taken to increase the capacity of the plant to such an extent as to handle all the ore shipped in. The furnaces will be enlarged and improved and a new stack 450 ft. high will be built. This stack will be the second largest in the world. The Murray plant, it is expected, will be operated on its new basis within six months.

A New Sampler at Salt Lake City

Due to the large output of ore it was found necessary to consider the erection of a new sampler at Salt Lake City. This sampler is expected to handle ores from Utah and the surrounding States. The new sampler will have an initial capacity of 750 tons per day, and will be so constructed that additional units may be added when found necessary. It will be of the Vezin type, and will cost \$75,000. Construction will be started as soon as the final details are worked out.

Cupellation Losses in Assaying

A study of the losses in cupellation assays has been published in the 1916 Bulletin of the School of Mines and Metallurgy, University of Missouri, by Profs. HORACE THARP MANN and CHARLES YANCEY CLAYTON. The topics considered are: Method of operation, screen analysis of bone-ash, losses due to composition of cupels, effect of moisture and hardness, effect of surface condition of cupel, and slag losses.

The Mode of procedure was as follows: The silver-foil used in these tests was carefully weighed and wrapped in lead-foil weighed to the nearest half-gram. When impurities were used, such as copper, tin and zinc, they were weighed accurately and added to the silver-foil and lead-foil button. Frequent analysis for gold and silver were made on all materials. Gasoline-fired muffles were used. Each run consisted of five rows of six cupels each across the muffle. The first row was placed about 3 in. back from the mouth of the muffle and acted as a guard to protect the experiments from any chilling effects. They contained

no buttons. Before placing the buttons in the cupels the latter were heated to 925 deg. C. to 950 deg. C. On placing the buttons in the cupels the muffled doors were shut until the buttons were well opened, and then removed and the temperature of the muffles maintained as constant as possible at that temperature where litharge feathers formed around the button. This temperature was maintained until 1 min. before the "blick," when the coolers were taken out and the temperature of the furnace raised. The cupellation was finished between 850 deg. C. to 900 deg. C. Platinum-platinum rhodium couples were used to measure the temperatures.

Screen Analysis.—The bone-ash used for all laboratory cupels gave the following screen analysis:

On	Screen	Size Opening, Inches	Per Cent
	28 mesh	0.0232	0.00
	35 mesh	0.0164	0.19
	48 mesh	0.0116	5.30
	65 mesh	0.0082	14.20
	100 mesh	0.0058	25.50
	150 mesh	0.0041	9.30
	200 mesh	0.0029	16.20
	220 mesh	.....	0.20
	240 mesh	.....	5.20
	260 mesh	.....	5.30
Thru	260 mesh	.....	21.70
			100.00

Losses in Cupellation When Using Different Materials for Cupels.—Nine different cupels were used in these tests—bone-ash, a mixture of one-half bone-ash and one-half cement, cement base with a bone-ash top, cement, Morganite, Braunitz, patented cupel No. 1, patented cupel No. 2 and patented cupel No. 3. Each cupel was charged with 20 grams of lead-foil and 20 mgs. of silver-foil. The results obtained are clearly indicated in Fig. 2, the best results being obtained by the Morganite and the Braunitz cupels.

Effect of Moisture and Hardness of Cupels on Silver Losses.—Five sets of cupels were made with varying degrees of moisture (5, 8, 12, 17 and 22 per cent). From each one of the above, cupels of various hardness were made. All of these cupels were then used

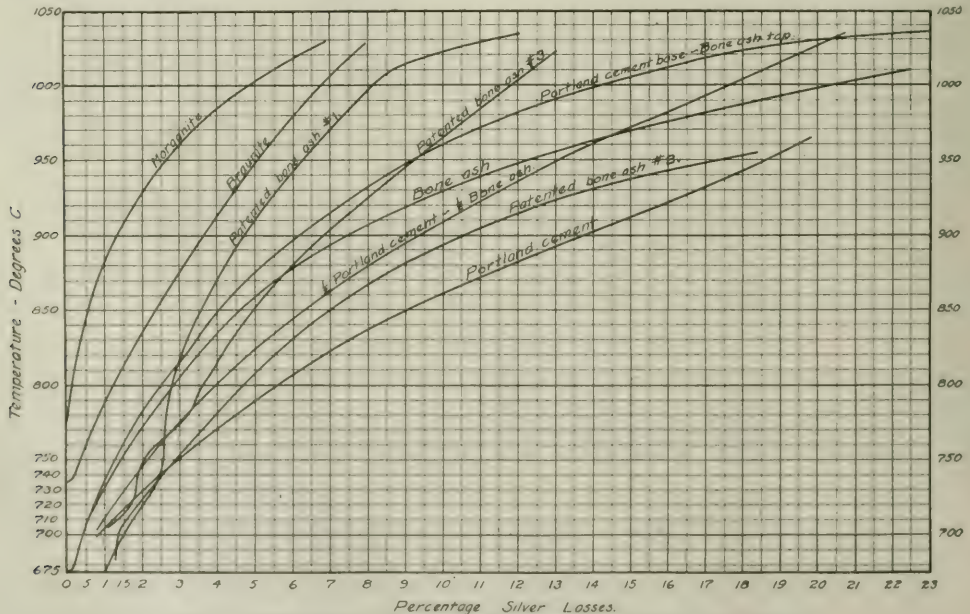


FIG. 2.—CUPELLATION LOSSES USING DIFFERENT MATERIALS FOR CUPELS

in the described manner, and the results obtained show that moisture and hardness have very little effect on the silver losses. The only effect worthy of notice is that the very soft cupels finish slightly ahead of the harder ones.

Effect of the Surface Condition.—The surfaces of the cupels were made more or less smooth by rotating them in the cupel molds. To obtain a rough surface the cupel, after removal from the mold, was scratched until all of the smoothness had been obliterated. The conclusions drawn from these experiments were that the surface condition of the cupel had practically no effect on the silver losses.

Effect of Size of Bone-ash on Cupellation Losses.—Sized bone-ash was used, the mesh used being 40, 60, 80, 100, 120, 150 and 200. From the results obtained it was found that providing the bone-ash passes 60 mesh, the size of the particles has practically no effect on the silver losses. It was also observed that all cupellations require the same length of time for completion.

Assay Slags and Silver Losses.—The authors, believing that the chemical composition of the slag effected the losses only to a very slight degree and ascribing the silver losses mainly to physical causes, such as imperfect decomposition, spitting, suspension of lead particles in slag and to volatilization, performed a series of experiments showing that under ordinary working conditions this holds true. The only conditions stipulated are those of good fusion. These are: Complete decomposition of the ore, formation of a fluid slag, furnishing the proper amount of collector at the proper time and keeping out of the lead button any impurities which might cause a subsequent loss. The mode of procedure was to make a number of fusions so as to give 50 grams of slag of a definite silicate degree, using standard reagents and keeping all conditions as constant as possible. A second set of experiments performed on silver ores under the same conditions as above, with the exception that the amount of slag formed varied, gave the same results.

The Joint Convention of the American Foundrymen's Association and the American Institute of Metals

A very enthusiastic gathering of iron and brass foundrymen and others interested in this particular branch of metallurgy occurred in Cleveland during the week of Sept. 11. The occasion was the technical sessions comprising the annual meeting of the American Foundrymen's Association, the American Institute of Metals, and the no less important exhibition of foundry equipment, appliances and materials held simultaneously at the Coliseum.

The technical sessions were inaugurated by a joint meeting on Tuesday, when subjects common to both societies were presented. On following days the two associations not only met separately, but on two mornings the foundrymen divided themselves into halves; on one occasion one section discussing electric steel while the other portion was considering malleable iron; and on another a session on gray iron and the other on steel castings were in progress. This made it difficult at times for the visitor of more or less diverse interests to make up his mind in which of the sessions he was most interested, then attend it, and submerge his regret that he could not be in three rooms simultaneously.

The program committee had arranged to devote only the mornings to the consideration of papers, hoping in that manner to secure a large attendance at the formal meetings, practically unaffected by the attraction of

such features as plant visitation, the exhibition at the Coliseum and the various social events. In this they were apparently successful, but one who had recently attended the strenuous Electrochemical Society meetings could not but wish that more of the day could have been devoted to the most interesting technical sessions. It was also to be regretted that some of the absent authors could not have been represented on the floor by a fellow member who could read at least an abstract of the paper. Lacking this opportunity, an important paper like that of A. F. Taggart on "The Reclamation of Brass Ashes" was passed with the formality of reading by title. However, the discussion of papers at the sessions of the Institute of Metals was especially noteworthy. When a paper had been presented, the discussion was usually spontaneous, sparkling and clarifying; in case the interest seemed to flag the chairman would call upon members who had not yet given their experience with the matters under debate to arise and unburden themselves for their own relief and their associates' profit.

As is perhaps well known, the American Institute of Metals is an off-shoot from the American Foundrymen's Association, organized some few years ago by those interested in the metallurgy of the nonferrous metals. That the child bids fair to outstrip the parent is evident from the membership—which in the case of the Institute of Metals has steadily grown up to half the size of the older organization, which on the other hand, is now nearly stationary in numbers—and from the fact that the daily attendance of the younger body was equal to at least 25 per cent of its enrolled membership, a point which the Institute members view with considerable pride.

Tentative moves toward reconsolidation were viewed with marked disfavor by the members of the Institute.

Their sentiments were perhaps best expressed by Vice-President Wallace, who declared that the Institute was eminently well fulfilling the purposes in view on its organization—that it had proved to be an invaluable meeting ground for men interested in all phases of the complicated metallurgy of alloys; a meeting ground where the engineer and scientist meet the metal founder, the latter sharpening his wits and learning the true reasons for certain reactions, and the former becoming acquainted with the needs and difficulties of the practical melter.

In this very manner the Institute itself seems, in the opinion of the writer, to be the most potent instrument leading to closer co-operation between the engineer and the foundry—a subject, by the way, treated with less virility previously during the opening joint session in a symposium by D. W. Sowers, J. H. Hall and G. F. Meehan from the founders' and C. E. Chase from the engineers' standpoint. As developed by this discussion, the foundrymen's chief objection to the engineer seems to be that he pays too little attention to the design of his castings so that they can be economically molded and cast without danger of shrinkage, cracks and spongy spots. The engineer, on the other hand, objects to the acceptance of castings made from peculiar foundry mixtures of "secret composition" and undetermined physical characteristics. It would seem that the precise knowledge available is such an infinitesimally small proportion of the whole field of alloys that engineers, in their ignorance, are constantly combining a chemical specification with impossible physical properties, and demanding a casting to suit. Dr. Moldenke closed the discussion with pointed remarks to the effect that co-operation between engineer and foundry was no longer desirable but absolutely necessary, and he advised foundrymen to make their sons first into engineers, and then into foundrymen.

The oration of the meeting was delivered, not at the banquet nor at the opening session, but at that same morning meeting when Mr. R. R. Clarke of the Pennsylvania System addressed the joint session, elaborating upon his most excellent paper—"Gating Non-Ferrous Metal Castings"—and wildly riding his hobby on "When is a Gate, and Why?" through the vanquished ranks of his opponents, to the huge delight of the innocent by-standers. Mr. Clarke not only knew what he was talking about, but he had excellent examples of his casting practice to exhibit to any doubting Thomas.

Following a strong appeal for fire prevention delivered by F. H. Wentworth, secretary of the National Fire Protection Association, both societies authorized committees to co-operate with that body. In the discussion a little appreciated fact was brought forth from the floor that in a recent design of a foundry addition, comparative estimates showed that an absolutely fire-proof steel and wire glass construction could be erected for about 75 per cent of the cost of a wooden "fire trap."

On Wednesday morning a long and most interesting paper by Charles Pack on the "Evolution of the Die Casting Process" was read. Mr. Pack has collected together an immense amount of archeological and historical lore regarding foundry practice from ancient times forward. He showed how metal founding had almost become a lost art during the dark ages, and even now had hardly recovered the high plane of the ancient handicraft. Mr. Pack thinks the modern die casting to be a direct descendant of the type founders' product, and the Mergenthaler linotype a notable example of the modern die casting machine.

When showing lantern slides of a wood cut illustrating a foundry of a century ago, some members exclaimed that it looked exactly like the modern foundry. Unfortunately it is too true. The exposition of foundry appliances, while notable and the recipient of many congratulations, exhibits only too clearly the necessity of another "Duquesne Revolution" which must strike the metal foundry to lift it out of the dirty, smoky, sweaty and superstitious condition it has inherited from the centuries.

Perhaps the most interesting paper presented on Thursday, Sept. 14, was by Mr. S. W. Miller, on the "Application of the Oxy-Acetylene Welding Process in the Repair of Defective Non-Ferrous Castings." He described an extensive series of experiments which he had conducted in developing an alloy which could be used under the blow-pipe for filling in cavities in brass castings. He pointed out that a perfect weld was impossible to make by any known process in a tin alloy, because under even gentle heating the very fusible tin eutectics would liquate at the joint, thus leaving a spongy muff about the welded insert.

Dr. P. D. Merica of the Bureau of Standards also emphasized the variation in chemical composition, physical constitution and internal strains existing at a welded or "burned-in" area in metallic substances in his paper on "The Initial Stress Produced by the Burning-In of Manganese Bronze." Too little consideration is given these non-homogeneous portions, sometimes with disastrous results; notably in the case of the failure of the large bronze valves at the Catskill Aqueduct.

On the final day of the Institute of Metals, Mr. P. E. McKinney, U. S. N., gave an interesting paper on the results he had been securing in the making of sound aluminium castings and forgings at the Washington Navy Yard. In this work he discovered that even the smallest amounts of iron, carbon or silicon entering into the aluminium alloy would weaken the metal and increase its brittleness. For this reason he recommends melting in a graphite crucible, clay-lined; stirring with

clay-lined tools; and avoiding heating the metal much above the melting point. Hot aluminium is very corrosive, and the best castings can be poured from metal under the dull red.

"Seasoning Cracks and the Self-Annealing of Brass" was discussed at length by W. Arthur, Frankford Arsenal, and other engineers interested in the manufacture of munitions, more especially of cartridge cases. They seemed agreed that the cracks occurred in places where an excessive galling of the metal had occurred during pressing. The proper steps for prevention, therefore, were evidently those leading to a more careful design of the dies used in forming the objects. Such seasoning cracks are particularly troublesome because they appear in a piece only after a decade's storage. Why it takes so many years for the crack to appear in an apparently sound piece of metal still remains an unsolved problem. It possibly may be due to the slow conversion of a metastable amorphous state caused by drastic cold working. At least it was agreed by those present that it could not be attributed to the excrement of the rodent inhabitants of the arsenals—an explanation advanced by one of the manufacturing firms and forwarded to the War Department. Co-operation between engineer and foundry has eliminated such ideas as these, at least. We have hopes it will go even further.

E. E. THUM.

Arizona Meeting of American Institute of Mining Engineers

The 113th meeting of the American Institute of Mining Engineers, which was held in Arizona from Sept. 18 to 23, turned out, as expected, a big success in attendance as well as in interesting features. This was the first time the Institute held a meeting in Arizona and the gathering was most enthusiastic. The prominence of Arizona as a copper producer (being now the leading district) and the large number of new smelters and mills erected there during the last few years made it an ideal place for a meeting. The meeting was in the form of a tour of the mining and metallurgical districts of the State with technical meetings held at various localities.

The Eastern party left New York, Boston and other Eastern cities on Thursday and Friday, Sept. 14 and 15, arriving at Chicago Friday evening in time for a ride around Chicago in autos and dinner at the Hotel LaSalle. They left Chicago late Friday evening, arriving at El Paso, Tex., Sunday afternoon, where they were enthusiastically welcomed by the Arizona members. A visit was then made to the smelting works in the vicinity, and to various points of interest around the city. An interesting feature in the evening was a Mexican dinner at the Toltec Club.

The party left El Paso late Sunday night arriving at Santa Rita, N. M., early the next morning. Here a very interesting and enjoyable inspection trip was made to the Chino Mines and Empire Zinc Co.'s works. At noon the party was treated to a barbecue, with the U. S. Military Band from Fort Bayard furnishing lively music. In the afternoon the party went to Hurley in automobiles and inspected the Chino mill where interesting developments in flotation work are under way. In the evening a dance was held in a temporary pavilion which was greatly enjoyed.

Leaving Hurley that evening the party arrived at Douglas, Ariz., the next morning, and the members were taken in autos to the Copper Queen Consolidated smelter, and the Calumet & Arizona Mining Co. A lunch was served at the Calumet plant.

In the afternoon a technical session on "smelting"

was held at which WALTER DOUGLAS presided. A paper was presented by A. G. MCGREGOR on "Features of the New Copper Smelting Plants in Arizona." (This was published in full in our Sept. 15 issue.) The paper was discussed by Sidney Jennings and E. P. Mathewson. An interesting paper on "Smelting at the Arizona Copper Co.'s Works" was then read by F. N. FLYNN. L. O. HOWARD's paper on "The Basic Lined Converter in the Southwest" followed. This was discussed by Messrs. Douglas and Mathewson and some interesting comparisons of the cost of Anaconda and El Paso converters and of the lining qualities was brought out. A paper by J. MOORE SAMUEL on "Determination of Dust Losses at the Copper Queen Reduction Works" brought out considerable discussion. E. P. Mathewson thought it advisable to collect the flotation concentrate dust in collectors and to build roasters to prevent dust as much as possible. Sidney Jennings advocated the use of a bag house. A. G. McGregor also participated in the discussion.

At the Tuesday evening session on "Leaching" WALTER DOUGLAS presided. H. W. MORSE and H. A. TOBLEMAN presented a paper on "Leaching Tests at New Cornelia." In a communicated discussion of this paper Lawrence Addicks said that graphite may succeed as anode material in the copper sulphate electrolyte, but that further experimentation was needed. Geo. D. Van Arsdale compared the advantages and disadvantages of lead and graphite electrodes. Messrs. Schimerks, Grabill, and Flynn also discussed this paper.

FREDERICK LAIST and HAROLD ALDRICH were the joint authors of a paper on "A 2000-ton Leaching Plant at Anaconda." Messrs. Flynn and Mathewson discussed the paper. LAWRENCE ADDICKS' paper on "Possibilities in the Wet Treatment of Copper Concentrates" was then presented. F. N. Flynn in discussing this paper advocated leaching flotation concentrates direct without roasting. A general discussion on leaching then took place, at which F. S. Schimerks described leaching at Clifton. H. E. Williams described the Calumet & Hecla ammonia process on tail dumps. Messrs. Mathewson and Van Arsdale spoke on wooden versus concrete tanks. Mr. Mathewson said wooden tanks were more economical for a small plant.

The party left Douglas late Tuesday evening arriving at Bisbee in about two hours. On Wednesday morning the mines in this district were visited and after luncheon a technical session was held on "Mining and Geology" at which GERALD SHERMAN presided.

The party left Bisbee late Wednesday evening, arriving at Globe Thursday morning. At Globe the mines and reduction works of the old Dominion Copper Co. were visited and after luncheon a technical session was held on the general subject of "Concentration and Flotation." A paper by DAVID COLE on the "Advent of Flotation in the Clifton-Morenci District, Arizona, 1914-1915," was presented. This was followed by the "History of the Flotation Process at Inspiration" by RUDOLF GAHL. (The first part of this paper is printed in full elsewhere in this issue.) In a communicated discussion of this paper Frederick Laist said that the pneumatic machine was better for alkali solutions and the non-pneumatic better for acid solutions. He also said that power was the main factor in the choice of a machine. Mr. Cole thought that elimination of classifiers was possible. E. P. Mathewson discussed practice at Montana and L. D. Ricketts thought that gravity concentration followed by flotation was best. The paper was also discussed by Messrs. Schimerks, Morse, Handy, Chase, Cottrell and Ruggles.

A paper on "Some Miscellaneous Wood Oils for Flota-

tion" was presented by R. C. PALMER, GLENN L. ALLEN, and O. C. RALSTON. "Flotation Concentration at Anaconda" was described in a paper by FREDERICK LAIST and ALBERT E. WIGGIN. In the discussion Rudolf Gahl said that wood oils retain part of the gangue, and asked why acid was added in one locality and not in another. Messrs. Ralston, Cole Watt, Gottsberger, Merrill, and Schimerks also participated in the discussion.

At the Thursday evening session several papers on mining were presented. P. G. BECKET acted as chairman.

On Friday morning a very interesting visit was paid to the reduction works of the International Smelting & Refining Co. and the mills of the Inspiration Consolidated Copper Co. and the Miami Copper Co.

On Friday afternoon a technical session was held on "Mining and Smelting," at which B. B. GOTTSBERGER presided. CHARLES LE GRAND presented a paper on "The Power Plant of the Burro Mountain Copper Co." The paper was discussed by Messrs. Gottsberger and Kidder. A paper on "Comparative Tests of the Marathon, Chilian and Hardinge Mills" was presented by F. C. BLICKENSDEFFER. In discussing the paper Mr. Gottsberger compared the Miami and Inspiration plants, and compared pebble mills with ball mills. Mr. Schimerks said there was linear action instead of spherical action in the Marathon mill. Messrs. Watts, Kiliani, Franke, and Merrill also participated in the discussion.

A fuller report, with notes on the concluding days of the meeting, is reserved for our next issue.

The Iron and Steel Market

The second half of September has proved in distinct contrast to the first half, for while the iron and steel market generally was rather quiet despite its distinct underlying strength it has since become decidedly active. What amounts to a real buying movement in steel products is now in progress, while the pig iron market has increased farther in activity, the demand resulting in an excited market with prices sharply advancing.

In the ranks of buyers generally there has been an accretion of confidence as to business conditions next year, whereby there is a general desire to cover. Three months ago jobbers and manufacturing consumers were alike doubtful as to the future, and were disposed to purchase only such material as it was absolutely certain they would require. First the manufacturing consumers began to conclude that the market would be strong and commenced buying on a more liberal scale. The jobbers were more reserved and it is only in the past fortnight that jobbers as a class are showing real confidence as to market conditions in the fore part of next year.

Apart from the steel buying that results from the buyers having greater confidence in the future there is an increase in the actual consuming demand. The railroads have entered the market again, after a long abstention from anything like liberal buying, and have bought a moderate number of freight cars, while there is now inquiry for fully 20,000 cars, despite knowledge on the part of the roads that very high prices will have to be paid, approximately double the lowest prices of the past. There is considerably more structural work coming to a head, investors showing a tendency to abandon the policy of waiting for the lower prices expected to obtain after the war. Contracting for ships continues heavy, even though the best deliveries obtainable now are in 1918. The Sinclair Oil Company is in the market for 800 miles of 6- and 8-in. pipe for oil lines to its projected refineries at St. Louis and Chicago, the lines involving about 60,000 tons of steel

plates. The automobile trade is urging the sheet manufacturers to accept contracts for the first half of next year, and price seems to be secondary to assurance of delivery.

There is a marked advancing tendency in steel prices. Bars, plates, shapes, sheets and wire products are all predicted to advance within the next fortnight, and it certainly appears that there has commenced another distinct buying movement in the steel industry, with the customary advances in prices.

Conditions Without Precedent

This is a period of unprecedented conditions, and this steel movement is entirely lacking in precedents, in that it follows, without an intermediate break, the previous movement. Never before in the history of the steel market has such a thing occurred. There have been buying movements of greater or less duration, and with larger or smaller total advances in prices, but in all the past each movement has been distinct, and periods of heavy recessions have intervened between the movements. The regular course is for buying to be heavy for a period, with prices steadily advancing, this being followed by a period of light buying and stationary prices, winding up with a market break and falling prices, with buyers holding off and waiting until prices approximated the cost of production before taking hold again.

The recent buying movement was on a modest scale during the first half of 1915, increasing in intensity in the late months of the year and extending through the first three months of this year. During the first nine months of 1915 price advances were moderate, averaging about \$5 a net ton on all important steel products outside of rails. In the next six months, through March of this year, the advances averaged \$20, or four times as much in two-thirds the time. In the four months April to July inclusive advances were merely sporadic, averaging only about \$2 a ton on all products. Following a period of such rapid advances and excited buying that period must be regarded as a dull one, with prices relatively stationary. At the beginning of August prices began to show a fresh advancing tendency, though only a slight one, but buying remained on a conservative scale. Now prices show a rather sharply advancing tendency and the buying is much freer. It appears to be a distinctly fresh movement, and in some quarters really famine prices are expected to prevail before the end of the year.

There is absolutely no sign thus far of high prices for steel cutting down consumption to such an extent as to increase the offerings. Steel is scarcer than it has been at any previous time in this general movement. Unfinished steel is practically unobtainable at any price, while in finished steel products the mills in the different departments are sold up practically as far as they are willing to sell.

Pig Iron Sharply Advancing

The buying of pig iron which began on a fair scale early in August developed into an excited movement in the last ten days of September, with considerable excitement and with prices advancing sharply. During the first half of the year pig iron had been practically stationary, following its moderate advance in the late months of 1915, and throughout the half year there were predictions that pig iron would eventually experience a sharp advance, the theory being that a scarcity would develop because steel making capacity was increasing while pig iron production could not be increased, and the full necessary supply had previously been eked out by drawing upon stocks. Not a single sign of scarcity appeared in July and August, perhaps because the hot weather in those months curtailed steel production

more than pig iron production. When the regular buying movement opened early in August the furnaces were ready to sell for the first half of 1917 at prices then prevailing for earlier deliveries and their readiness to do this was far from suggestive that they themselves expected a scarcity. The selling represented the familiar accumulation of "back log tonnage," a practice not conducive to a stiffening in prices. If the furnace interests had had a moderate degree of courage, a moiety of that shown right along by the sellers of steel, they could have secured much higher prices for their iron as the buyers needed iron and were in no position, with their large profits, to quibble over pig iron prices. Eventually, however, the furnaces got through building up the backlog, and as soon as they showed any reserve about selling, the market started to advance sharply. In a few days Bessemer pig iron at valley furnaces jumped from \$21 to \$22.50, with large sales at intermediate prices and at the top, while at this writing the material appears to be very scarce and may advance farther. Basic pig iron similarly jumped from \$18 to \$19, valley. Foundry iron, which had advanced slowly from \$18.25 to \$18.50 moved up to \$19 in sympathy with basic. Other pig iron producing districts showed a stiffening tendency but did not advance sharply, as they were not under the control of steel making iron as is the case with the valley-Pittsburgh district.

Unfinished Steel

The fourth quarter price on Carnegie sheet bar contracts is understood to have been fixed at \$42, but there are slight concessions from the regular price in the case of most of the mills. The advance over third quarter amounts quite uniformly to about \$5 a ton, and a further advance for the first quarter is to be expected. There is practically no market for billets and sheet bars as there are no offerings to speak of and the average consumer could not afford to pay prices that would be asked, \$45 to \$50. Consumers are simply operating upon such unfinished steel as is coming to them by reason of old contracts. There is a large export demand, which cannot be satisfied. There has been increased export buying of billet discards produced in making shell steel, not because this particular material is desired but because nothing else can be had.

The nineteenth annual session of the **American Mining Congress** will be held at Hotel La Salle, Chicago, during the week of Nov. 13. The seventeenth floor of the hotel has been engaged for exhibits and considerable space has already been taken. Mr. James F. Callbreath is secretary of the Congress, and his headquarters are Rooms 213 and 214, Hotel La Salle, Chicago.

Trade and Tariffs in South America.—The Federal Trade Commission has issued a report on trade and tariffs in Brazil, Uruguay, Argentina, Chile, Bolivia and Peru. The report is the results of a study made by the Federal Trade Commission of conditions in the above named countries and its scope may be understood by the following quotation from the letter of submittal to Congress. "Realizing how vitally tariff laws and regulations affect the movements of commerce and believing that a study of them would be useful to both the Governments and the business interests of all the American Republics, the Federal Trade Commission has sought to point out in the trade conditions and in the customs laws and practices of Latin America the obstacles encountered, and at the same time to indicate to American business men and to the Governments of both North and South America how these obstacles may be wholly or partly removed."

New York Meeting of American Chemical Society

Opening Session

The American Chemical Society opened its fifty-third annual convention on Tuesday, Sept. 26, with a general meeting in the auditorium of Horace Mann School, Columbia University. The chairman of the New York Section, Dr. J. MERRITT MATHEWS, presided. The first speaker was Dr. HADEN EMERSON, Health Commissioner of New York City, who urged chemists to devote part of their time to the education of the workmen in the plant. He outlined the work of the Health Department of New York City in the prevention of occupational diseases. He said it was creditable that a session was to be devoted to this subject during the convention and that a permanent section of the American Chemical Society should be formed for the supervision of the working conditions in factories.

Dr. NICHOLAS MURRAY BUTLER, president of Columbia University, welcomed the society to Columbia and expressed the wish that all feel at liberty to inspect the University and make use of its facilities. He paid a splendid tribute to the work of Dr. Emerson, and said that from observations made on a western trip which he had just finished, he found that the scientific problem and the human problem everywhere tend to coalesce. It may be health, ease of operation or other consideration, but the human problem always comes in, as does also the scientific problem. President Butler said that the gathering this week was a mobilization of forces of the country, a large part of civilization's fighting army.

Dr. CHARLES H. HERTY, president of the Society, extended the thanks of the society to the New York section and to Columbia University for the arrangements of the meeting and the privileges extended.

He then called upon Dr. DAVID T. DAY, who outlined the plans of the Joseph A. Holmes Memorial Association for furthering the workmen's welfare and safety work started by the late Dr. Holmes when director of the Bureau of Mines. Dr. Day urged all to give the matter their moral and financial support so that something definite might be accomplished in the form of a nation-wide movement.

Secretary CHARLES A. PARSONS then read a letter from the American Association for the Advancement of Science, advocating a general meeting every four years of all scientific societies in some large city, in the interests of science in general. Dr. Parsons explained that the American Chemical Society had agreed to meet with the Association in December, but changed this decision on account of the Chemical Exposition.

A resolution was introduced and passed that the society endeavor to meet with the American Association in December.

COLLOID CHEMISTRY

Following the business session, two papers were presented. Dr. WILDER D. BANCROFT read a very interesting paper on "Colloid Chemistry" in true Bancroft style. He defined colloid chemistry as the chemistry which has to do with substances which are in a state of very fine division. He gave a long and imposing list of industries in which it plays an important part. A few of them are: Cement, brick, asphalt, pottery, varnish, soap, rubber, milk, butter, purification of water, sewage, photography, but there were many more. He said that our knowledge of colloid chemistry was getting on a firmer working basis, and gave an outline of the present state of the theory from the viewpoint of adsorption.

All liquids and solids adsorb gases. As examples we have the case of broken china. The formation of an air film prevents its sticking together again. It is difficult to make two soap bubbles coalesce due to the formation of an air film. Certain colloidal substances will coalesce immediately after being broken, but if they are left to stand awhile, they will not. It takes time to adsorb the air film.

Solids also adsorb liquids, a phenomenon of which there are many common examples such as the adsorption of water by various solids, with which every chemist is familiar.

Solids also adsorb solids, for example, in polishing with rouges, the rouge sticks to the polished surface unless it is kept moist. Passive iron is due to an adsorbed film of iron oxide. Dyeing is another example. The fiber of the fabric adsorbs a film of the dyestuff.

Adsorption is always selective, i.e., the same substance will adsorb different amounts of different substances. As a first generalization it may be stated that a multivalent ion will be adsorbed more readily than one of lower valency. Solubility is a case of specific adsorption.

If a substance which ordinarily sinks in a liquid is ground fine enough it will remain suspended on account of the bombardment of the particles by the molecules of the liquid. This is the so-called Brownian movement, and is visible by the ultra-microscope.

Colloidal solutions can be made by precipitation, but it must be done in the presence of a substance which is strongly adsorbed. A substance in suspension exerts no osmotic pressure except in so far as there is a solution, consequently the boiling-point method of determining molecular weights is not accurate, as it is not the amount of substance which is added to a liquid which counts in this case, but the amount which goes in solution.

If a protective film which covers the particle be removed by a chemical reagent which dissolves it or precipitates it, then the particles will fall. They coagulate. An electric current will sometimes maintain finely divided particles in a colloidal state by giving each a negative charge so that they repel rather than attract one another. On the other hand, alternating currents of high frequency such as used in the Cottrell process will often cause them to coalesce and thus fall down upon the baffle plates set to catch them. By this means the particles are removed from smoke and fumes.

BY-PRODUCT COKE OVENS

Mr. HORACE C. PORTER read a paper on "Coal and Coke By-Products As a Source of Fixed Nitrogen." He showed that there was sufficient nitrogen available from by-product coke ovens for all our war needs.

The annual capacity for ammonia at coke plants is 113,760 tons of NH_3 . At gas works the capacity is 12,500 tons, making a total of 126,260 tons. The practical yield of 95 per cent nitric acid from this ammonia would be 404,000 tons. Our war needs are estimated at 180,000 tons of nitric acid. Mr. Porter thought the proposed Government nitrate plant would hurt the private producers of nitrogen compounds.

Tuesday Afternoon Session

At the public meeting Tuesday afternoon in the Horace Mann Auditorium Mr. JOHN E. GARDIN, vice-president of the National City Bank, New York City, was the first speaker. He said the great fear was that our attempts to build up large chemical industries would be only sporadic, and that Europe would take the fore again when peace was declared. He said we must

create stability in our production. American banks do not have free power to help the industries as the European banks do, on account of banking laws, but capital is available whenever a reasonably satisfactory proposition is forthcoming.

General WILLIAM CROZIER, chief of ordnance of the War Department, said that chemists were needed to help the government with the nitrate plant. The chemists' services are indispensable to the government.

Dr. CHARLES H. HERTY, in his presidential address, laid great stress on the need of co-ordination of effort in establishing our industries. The universities should increase their budgets to their chemical departments so that the increasing demand for men and research work may be met. More graduate fellowships are needed. We must have more detailed information on importations. Our government statistics are now inadequate. Dr. Herty said that provision should be made by the government for storing large quantities of toluol, which will be available from our overproduction after the war. He urged greater investigation of alcohol as a motor fuel. He reviewed the great fight for a dyestuffs tariff extending over the last two years and culminating in a bill which was not satisfactory. He said the American public will not stand for such legislation. Chemistry is occupying a more prominent place in the national thought, as evidenced by the increasing reports in the public press.

Division of Industrial Chemists and Chemical Engineers

The Industrial Division held a meeting in Schermerhorn Hall, Columbia University, on Wednesday, Sept. 27, at which several interesting papers were presented, which elicited considerable discussion.

The "Brewing Industry" was discussed in a paper by CARL A. NOWAK. He said that the brewing industry was entitled to recognition, as it was a scientific industry on a firm basis, and needed the help and recognition of the universities and scientific men in advancing the methods of manufacture.

J. W. TURRENTINE presented a paper on the "Present Status of the Potash-from Kelp Industry of the Pacific Coast."

The "Preparation of Oxalic Acid and Citric Acid by Fermentation" was described by JAMES N. CURRIE.

The "Manufacture of Benzaldehyde and Benzoic Acid" by a new process was described by H. D. GIBBS. The work has been more or less of an experimental nature, but a large-size apparatus is at present being constructed by Mr. Gibbs, and the process seems to offer possibilities. It consists in subjecting toluene and chlorine in the gaseous state at 110 deg. C. to the action of ultraviolet light and other catalysts with the formation of benzal chloride and benzol trichloride. This is converted by hydrolysis into benzaldehyde and benzoic acid. A large number of catalysts were tried, among them being the oxides of Al, Bi, Cr, Mg., and many others. Some of these gave promise of good results. Tests so far gave a conversion of 10 per cent of the original toluene into benzaldehyde and 1.5 per cent into benzoic acid. Upon separation by distillation 75 per cent of the toluene is recovered.

W. C. TAYLOR described a new glass called "noviol," which absorbs the ultraviolet radiations, and can be used for many industrial purposes. One variety is used for arc welding glasses, another variety for filtering light in chemical works, and another in microscopic work under artificial light.

A paper on "Single and Multiple Effect Evaporators" was presented by OTTO MANTIUS. This paper will be printed in full in a later issue. It gives information of great value to those having evaporating prob-

lems. In the discussion of this paper it was brought out by Mr. Mantius that for caustic solutions the iron tubes in the evaporator should not contain more than 0.03 phosphorus. He said there was no one material for tubes which would be good for all liquors. Copper is too expensive at the present time to use, but makes very good tubes. Mr. Mantius said he had found difficulty in getting anyone to make tubes of the proper quality, but that experiments were being made for him by a manufacturer at the present time along this line.

The "Cheap Production of Alcohol" was discussed in a paper by ARTHUR N. BRECKLER. He said there were two uses for alcohol, viz.: as a raw material in the industries, and as a fuel. At the present time the largest uses of alcohol are in the hat and tobacco industries, and also since the war in the munitions factories. Mr. Breckler thinks the big future for alcohol is as a motor fuel. He said to compete it must be made for not over 10 cents per 160 proof gallon. In 1914 we produced 182,000,000 gal. of alcohol, which is about 5 per cent of our present gasoline consumption. This alcohol is mostly produced from grain, corn, malt, and rye. One other large source is black strap molasses, but to be a commercial proposition the black strap must not cost more than 5 cents per gallon. It is now selling at 12 and 14 cents, and is almost impossible to obtain, on account of the increasing demand for molasses. Other sources are wood waste and sulphite waste from pulp making. These so far have not achieved any great success, but offer possibilities. In considering an alcohol process the cost of coal and water costs for cooling must be considered. There are a lot of abandoned alcohol plants which have been unsuccessfully operated. Grain is too high to make alcohol from to compete as a motor fuel, and molasses is rapidly becoming too high. Other sources must be found.

An interesting paper on "The Use of the Cottrell Precipitator in Recovering Phosphoric Acid" was presented by W. H. ROSS, J. N. CAROTHERS, and A. R. MERZ, of which the following is an abstract.

An investigation on a semi-commercial scale has been made of the use of the Cottrell precipitator in recovering the phosphoric acid evolved in the volatilization method of treating phosphate rock by ignition with coke and silica in an electric furnace. A current of air which was passed over the charge in the furnace served the double purpose of oxidizing the fumes of phosphorus to phosphoric anhydride and of carrying the latter to the precipitator. In one series of experiments the fumes from the furnace before entering the precipitator were passed through a tower provided with baffle plates which had the effect of cooling down the gases to about ordinary temperature. In a second series of experiments the tower was cut out and the fumes passed almost directly into the precipitator at a temperature above 100 deg. In each case the phosphorus anhydride, which takes up water from the current of air passing through the furnace and also from the moisture driven off from the charge, is precipitated in the form of a solution of phosphoric acid. When the precipitation is made at temperatures above 100 deg., the acid obtained is not only more concentrated, but also of a higher degree of purity, with respect to volatile constituents than that recovered at lower temperatures.

The advantages of this method of collecting the phosphoric acid over the scrubbing tower method now in use are as follows:

- (1) The equipment required is simple in construction and automatic in operation.

- (2) The simplicity of the construction of the precipitating pipes decreases the difficulties arising from the corrosive action of the phosphoric and hydrofluoric acids evolved from the phosphate rock.

- (3) The phosphoric acid recovered in this way is of a high degree of purity and is thus suited for direct use without further purification in those industries where a relatively pure acid is required.

- (4) A more concentrated acid can be obtained in this way than by any other commercial process, and when this acid is used in the preparation of concentrated fertilizers, such

as mono-ammonium phosphate, a dry product may be obtained directly without the necessity of evaporating solutions, or of drying the resultant product.

This is the first time that the Cottrell precipitator has been used for the precipitation of a product which has been volatilized with a view to its recovery in this way.

Colloids

The Industrial Division met on Thursday in joint session with the Sections of Physical, Inorganic, and Biological Chemistry, which session took the form of a symposium on "Colloids."

On Wednesday morning the Biochemical, Physical and Inorganic Divisions held a joint session on "Colloids" in Havemeyer Hall, Columbia University. Several interesting papers were read presenting different phases of this interesting subject, which at present is receiving so much attention.

On Thursday morning the joint session of the Biological, Physical, Inorganic, and Industrial Divisions continued the symposium. A paper by Dr. CHARLES BASKERVILLE on the "Refining of Oils" was supplemented by experiments illustrating his process, which consists briefly in treating crude cotton, soya bean, and other oils with cellulose fiber (about 0.25 per cent by weight), adding a determined amount of caustic soda, heating, then adding a small percentage of sodium sulphate or carbonate and filtering. A more complete description of this process which is now being operated on a commercial scale was given in our issue of July 1, 1916.

A paper by Dr. COLIN G. FINK dealt with the "Relation between Chemical Composition and Electrical Resistance."

The paper describes a series of experiments carried out in support of the author's theory that the electrical conductivity of substances in general is primarily dependent upon the shape and distribution of the fundamental grains or particles composing the substances, and secondly, upon the presence or absence of thin films of secondary material ("cement") enveloping these ultimate grains.

T. R. BRIGGS discussed colloid chemistry as applied to the paint industry.

L. A. KEANE presented a paper on "Yellow Bricks." This paper was read by W. D. Bancroft.

The "Vulcanization of Rubber" was discussed by D. SPENCE. This paper gave the latest and most plausible theory of rubber vulcanization, proposed first by a Russian chemist, viz., that a definite rubber compound is formed which is distributed through the rubber forming a two-phase system having different properties than either the rubber or the rubber compound. Thus when using sulphur a rubber sulphide is formed which is distributed through the rubber.

W. D. RICHARDSON discussed the "Splitting of Fats" and A. W. DAVISON the "Absorption of Chromium by Hide Powder." Other papers were read on "Asphalt" by C. RICHARDSON, "Plaster of Paris" by L. A. KEANE, "Emulsions and Suspensions with Molten Metals" by H. W. GILLET, "The Purification of Kaolin" by C. L. PARSONS, "Colloids in Glass" by ALEXANDER SILVERMAN, and "Fritting and Fusing" by W. D. BANCROFT.

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A series of industrial conferences was held each afternoon, commencing Wednesday, at which were discussed various subjects of importance such as dyes, glass, etc. A fuller account of these and of some of the other meetings is reserved for a later issue. The reception which was held Tuesday evening at the Hotel Astor and the banquet Friday evening at the Waldorf-Astoria were well attended by members of both the chemical and electrochemical societies, and other visiting chemists and engineers.

New York Meeting of American Electrochemical Society

The thirtieth general meeting of the American Electrochemical Society was opened on Wednesday, Sept. 27. Fittingly the opening session was held in the lecture room of the Chemical Exposition at the Grand Central Palace, as Wednesday was "Electrochemical Day" of the Exposition.

Dr. COLIN G. FINK, chairman of the New York Section of the society, presided.

Mr. ADRIAAN NAGELVOORT, one of the managers of the Chemical Exposition, made a felicitous little speech of welcome in which he spoke of electrochemists as live wires and of the automobile in the Electrochemical Society booth of the Exposition as just one example demonstrating clearly how electrochemical processes and products are revolutionizing the industries of the country.

PRESIDENTIAL OPENING ADDRESS

An address by the president of the American Electrochemical Society, F. A. J. FITZGERALD of Niagara Falls was then read by Dr. JOHN A. MATHEWS, as Mr. FitzGerald was unfortunately detained in Niagara Falls by sickness. Mr. FitzGerald's scholarly address is herewith given in full:

When I emigrated to the United States nearly a quarter of a century ago I was immensely struck with the great stress laid on the word "imported" when buying anything. The excellence of the goods would be freely explained by the salesman, but he generally reached a climax when he pointed out that they were "imported."

Before coming to this country I do not remember observing that excessive modesty was a characteristic of its citizens and yet the enormous respect paid to imported goods seemed to imply its existence.

Here, as everywhere else, we find that we can do better in many cases by using articles manufactured in other countries, but the mere fact of being imported is hardly a proper recommendation. Some years ago when in Germany I visited a large steel plant where the guide apologized for some rather antiquated rolling mill machinery which he showed me, but when we had looked at this he conducted me with pride to another mill where he said they had American machinery or at least machinery of American design. Again you may see shoe factories in England which are said to be very efficient establishments because they have American machinery. And so in various European countries you will find things are represented as having certain excellent qualities because they come from some place where such articles have a well deserved reputation, but I do not remember having ever heard of a thing being recommended just because it was imported.

Now the existence of an idea that because something is imported it must be of greater excellence obviously involves the tacit assertion that things made in this country are inferior. This attitude towards imported articles has, I think, been considerably modified in recent years, and as a means of bringing about this desirable modification, exhibitions such as this of our chemical industries are of immense value.

When the United States were sparsely inhabited and there were relatively few industries, they had to depend for many things on importation, and so it came about that an indiscriminating belief in the excellence of imported articles developed and this as regards many of these things exists even to-day.

Certainly in such matters it is not desirable to attempt to develop any spirit of nationalism which would induce us to support a home product which is inferior to the imported, but it is always well, even from a purely selfish point of view, to investigate what can be done at home before going abroad, and even if the home product is inferior to try and find the cause of its inferiority and then if possible to assist that industry to equal or excel the foreign product. Here again we find a valuable function of a national exposition such as this.

In various industries the United States is now in a position where it is well to the front or actually leader and I think we may assert without fear of contradiction that the electrochemical industry is one of these. The field is comparatively new and we did not start in it with the handicap

which existed in many of the older industries. In certain industries covered by the general term electrochemical we certainly have the foremost place—for example, in the manufacture of artificial abrasive materials. In other cases (such as the application of the electric furnace to steel) we have lagged behind until recently. Again in others we are a long way behind developments in Europe, as in the fixation of atmospheric nitrogen.

It is well worth while studying those subjects in which we are not or have not been in the front rank in order to determine why this is so. Thus a study of the development of the use of the electric furnace for the manufacture of steel seems to show that special conditions in Europe tended to stimulate the development there and that it was actually to our advantage that the pioneer work should be done there rather than here so that we have no cause to regret that while the pioneer work in this branch was being done in Europe we were busy in other directions.

On the other hand, the study of the development of electrochemical methods of nitrogen fixation shows a different reason for our backward position. Those not conversant with electrochemical history are apt to believe that this is altogether a foreign development, never having heard of the work of Bradley and Lovejoy at Niagara Falls more than twelve years ago. Here then we had a remarkable development that was arrested because of adverse environment. For in Europe when similar developments took place it was possible to obtain abundance of cheap electric power. When the question of "National Preparedness" is in everyone's mind we are asked what is to be done about the preparation of nitrates, for in this respect we are by no means ready, and the Committee on Public Relations of the American Electrochemical Society in its report to the administration on this subject recommends "a liberal water power policy, as the question of the cost of power is vital to several of the processes."

These examples show the value of a study of our position in the electrochemical industry and similar studies in other fields should also give profitable results. The electrochemist uses a great variety of materials and articles: chemicals, physical apparatus, electrical machinery, etc., some made in America, others abroad. It was with this in mind that the Electrochemical Society decided that at its meeting held here at the same time as this great National Exposition of Chemical Industries it would be of interest and value to devote a whole session to the subject "Made in America" as related to electrochemical interests.

This discussion of the subject should be useful in several ways. It may help to develop a more critical study of imported materials and articles, and this is very necessary, for it is a fact that we are often apt to be less critical of an imported than of a domestic article, and there can be no doubt that the foreign manufacturer often likes to unload on us materials which he could not sell at home.

As an example of this I may mention the advice I received from an eminent American physicist who gave me the address of a well known German manufacturer of thermometers; said he, "When you place your order tell him that you know what good thermometers are and that you don't want him to send any of the poor quality which German manufacturers think are quite good enough for American consumption."

In other words the discussion of "Made in America" will stimulate a more discriminating appreciation of imported articles.

Another useful end will be served if the discussion of it reveals why the domestic product does not give the satisfaction which the imported material does. This may develop much needed co-operation of the consumer and the producer. There has not been enough of this. If the domestic article is not satisfactory the consumer has been in the habit of throwing it out and using the imported article without having sufficiently long sight to see that it was worth while to co-operate with the producer in helping him to better his manufacture.

It is perhaps getting dangerously near a political question, which ought not to be political, to say that mutual co-operation of producer and consumer is in the long run of far more importance than protection, which is sometimes apt to encourage the manufacture of inferior articles.

Perhaps then, one of the greatest uses of such an exhibition as this is the way in which it brings together the manufacturer and the consumer to their mutual benefit and for this we surely owe a debt of gratitude to those responsible for it.

"Made in America" Session

The morning session of Thursday, held at the Hotel Astor, was devoted to the subject "Made in America," and turned out very interesting. Great credit is due

to Mr. L. E. Saunders, chairman of the "Made in America" committee, for having made the arrangements. Mr. F. A. Liddbury presided during the session.

Mr. L. E. SAUNDERS introduced the subject by a general statement of how the committee had proceeded and quoted different opinions concerning the question whether a "Made in America" movement should be carried on along the "slogan idea."

Mr. ACHESON SMITH then discussed this very question in an interesting paper. The use of such an expression as "Made in America" may induce the use of American-made goods through patriotic motives, but such an appeal would be limited to Americans and would be of doubtful value.

If, on the other hand, the expression "Made in America" is simply to focus the attention of people, both at home and abroad, upon the fact that the goods are made in America, it would seem axiomatic that such goods must be of the very highest possible quality and sold at a reasonable price, or the expression "Made in America," would soon be a warning against American-made goods instead of an argument therefor. If the slogan "Made in America" could be limited to goods of the highest possible quality, which would have to have the approval of some central body or governmental bureau before the makers were permitted to use such expression, the slogan might become a sort of hall mark for quality, which would in time induce many people to demand American-made goods upon the assumption that everything bearing the expression "Made in America" was of the highest quality. Unfortunately, it does not seem possible to establish standards by which every article of manufacture can be measured, nor any bureau to which it would be safe to give the power of granting of withholding permission to use "Made in America." If the manufacturers of the best goods produced in America should use the expression "Made in America," we would naturally expect others who had difficulty in selling their goods, owing to poor quality or unreliability, to use the same slogan as a cloak to enable them to gain a standing which they do not deserve. If this should continue to any great extent, and it seems that it would be a very probable tendency, the use of the expression "Made in America" would likely be of more harm than benefit to American goods, for the simple reason that comparatively few instances of inferior quality would become more widely known and be remembered longer than many times the number of cases of high quality goods which have given satisfaction. It would simply be a case of bad news traveling faster than good news.

The whole question of selling goods in foreign countries is one of economics, and not a question of national trade mark. As a nation the value of our imports must equal our exports, so we will probably continue to import the goods we do not produce, or which are of a better quality than we make, and we will continue to export the goods others do not make, or which are preferred owing to their quality. As other countries may commence at sometime to manufacture goods formerly imported, it would therefore seem evident that the only part of our foreign trade that is secure is the portion based on quality. If we manufacture and sell inferior articles, they cannot be a dependable part of our foreign trade.

One of the fundamental items in preparation for export trade is for a manufacturer to test his product in comparison with similar products made in other countries, and if his article does not prove to be the best, he should go back over his manufacture and leave nothing undone to make his output of a better quality than that of his competitors. Having thus made sure by actual test that his product is as good or better than competing articles, he should take pride in placing his own name and trademark thereon so that his product may be identified, and if he is then willing to stand squarely behind his product, he will have done the most important thing that can be done for himself and for the foreign trade of the United States. If the manufacturers are desirous of gaining or extending their trade in other countries, they should be willing to put their goods to the supreme test of actual comparison, and when their goods are able to stand up under such test, they are then prepared to enter the foreign field having their business based on the bed rock of quality. Any success which follows they will of course enjoy and the benefit to the United States will naturally ensue.

Mr. F. A. SCHRAMM of the Bureau of Standards was the next speaker, reviewing in an interesting way the

experience of the Bureau of Standards with apparatus and materials which are now being made in this country and were not made here before, at least to the extent of their present manufacture. He reviewed the progress made in the manufacture of balances, iron-nickel alloys for standards of measurements ("invar"), cloth for cement analysis, meters and other electrical instruments, thermometers and pyrometers. With respect to materials he discussed pure platinum for pyrometer work, optical glass and instruments, pure metals, chemical glassware, ceramic products, porcelain, and referred to the necessity of blending clays for crucible manufacture. It was a very interesting report of progress with an occasional word of helpful criticism. The author concluded by emphasizing the necessity of the use of the metric system for export trade.

Mr. L. E. SAUNDERS then reviewed the progress made in American manufacture of such products which concern more directly the electrochemical industry. He started with carbon electrodes.

Before the European War started, we cannot deny the fact that a large quantity was imported from various European countries. The number of replies to our inquiries from users has been extremely gratifying. Every user of whom we have inquired, has stated that it is possible to secure, in this country, large electrodes of as good a quality as was purchased abroad two years ago. There is, of course, a possible erroneous conclusion here. It has been brought to our attention that progress may have been made with the European manufacturers and as great an improvement may have resulted as has been experienced in this country. One user states that when the war started there were no carbons of large size to be compared with those of European manufacture. Another user states that some of our carbon manufacturers have been successful in improvement and others are not doing as well as they did when severe competition had to be met. Still another user says that they are unable to furnish any testimony in this respect as they have used nothing but American-made electrodes. Undoubtedly, these latter people would come in the class, favoring a slogan "Made in America," and the purchase of articles bearing that slogan, whatever their quality might be.

Some users have gone into detail in the matter of carbon electrodes, and have stated: First, that the perfection of manufacture is very high in our American-made carbons. Second, that the resistivity is even less than the best of European carbons and that annealing has been so perfectly done that breakage almost never occurs. This user is, of course, an enthusiast, for those of us who use carbon electrodes realize the Utopian nature of the last statement.

One of the complaints that has been made by a user is that the price of European electrodes delivered was about 40 per cent. less than the cost of the best American electrodes during the past year, and that there is no such difference in quality as to warrant such a difference in price. It is, perhaps, needless to point out that we do not know what the cost of European electrodes might now be delivered in the United States, but it is safe to say that it would not be the cost at which they were sold two years ago, and there is at least a question whether such a difference in price will occur again when the manufacturers meet in competition.

I turn now to the use of electrodes in the electrolytic field, and here, again, I am obliged to say that there has been no adverse testimony of American-made articles, in fact, they have so uniformly favored a single manufacturer, that it becomes embarrassing to make any statement. In only one instance has testimony come in where a carbon electrode has been used in wet electrolytic work and even in this case it is reported that those purchased in this country were preferable to those secured from abroad. All our other testimony on this subject states that graphite electrodes are used.

The next subject on our list, and one which necessarily is of a restricted nature, concerns the metal, platinum. One of our most prominent professors of electrochemistry has stated in a letter that no American-made platinum makes any pretense of being good. Other users state that platinum vessels have been supplied by American manufacturers containing so much iron and iridium that they cannot be used for accurate analytical work and are attacked when used on a large scale in other ways. This is a serious arraignment of American-made articles.

(Mr. Saunders referred to one reply he had received from

an American platinum manufacturer to the effect that competition of years had been successfully met by American-made articles, and that there has been no demand for quality of products that the American manufacturer has been unable to supply, and reference was made to a report of a committee of the American Chemical Society confirming that as good platinum can be obtained from American manufacturers as from abroad.)

I shall briefly mention, only in passing, the subject of ferro alloys. The quality of the products of this character made in this country have always been, almost from the time of the beginning of the industry, of the highest possible character. Unless we, here at this meeting to-day, hear something to the contrary from some one with experience, I think it can be safely said that so far as the article manufactured is concerned no hardship has been suffered with respect to ferroalloys. I do not refer now to the question of securing raw materials and ores which enter into their manufacture, but simply to the skill and art of the manufacture itself.

I mention, in the same manner, the subject of electric steel. The testimony at hand has not been large, and it may be that something has escaped in the investigation. I know that special steels have been made abroad which, during the early part of the shortage here, could not be duplicated. This, I believe, is rapidly being overcome and I feel safe in saying, subject to correction at this meeting, that electric steel, in all qualities, made in this country has never been excelled.

Perhaps the matter on which we have received the greatest amount of testimony is in connection with the chemical glass industry. The users are, to a considerable extent, pessimistic. Quoting from a well-known college professor, the statement is made: "American glassware is very much inferior in workmanship, in most cases in quality, besides costing anywhere from two to five times as much." Another large user states that we cannot make a suitable glass without potassium and the proper silicates, nor without the proper clay materials for the pots, and these are not obtainable in this country. The same user is extremely pessimistic about remedying this situation. He states that in many cases abroad it is a family affair, the making of fine glassware, and the son follows in the father's footsteps, these men not being willing to leave their country, and when they do come, they can command better wages than the industry can afford to pay. Another user states that compared with Jena glass, certain American made glasses are more resistant to the action of both acids and alkalis, especially the latter, for example: When boiled in 10 per cent sodium hydroxide solution, its loss in weight was less than 60 per cent of that sustained by Jena glass under the same conditions. Its resistance to shock and to sudden changes of temperature seems to be somewhat better than certain imported glassware. Another user states that resistance to sulphuric acid was higher in the case of American glass than of the best imported glass. Still another user placed test tubes filled with distilled water in an autoclave and kept them there for 45 minutes at 12 lb. pressure. No trace of alkaline or acid substances was found in the water with a large number of indicators. Very few foreign glasses, it is stated, can withstand this test. On the other hand, one user states that he is unwilling to publish the data he has obtained on both glass and porcelain for patriotic reasons. This statement certainly should draw out something from those present here.

We have been furnished with a large amount of data by manufacturers and all are agreed that our greatest difficulties at present are with light blown glassware. While workers from abroad have been brought to this country, the demands are so heavy with the European supply cut off, that hardly a beginning has been made in meeting the demand. Wages for this class of labor have gone up on account of the great demand, so that prices have also increased. It may be said, however, that this kind of ware can be produced in this country and it is simply a question of quantity rather than quality that is troubling the user. The manufacturers of glassware have stated, in one case, that the linear thermal expansion has been reduced in the glass of his manufacture to just about half that of the imported glassware. He states that fewer constituents are contained in the glass, which may contaminate solutions in analytical and other delicate chemical work, for instance: This glass is free from the elements calcium, magnesium and zinc. Tests of a glassware for solubility in distilled water showed a very much smaller solubility than with the German glassware, kind not stated. This same manufacturer gives results of tests in regard to breakage on sudden cooling. The beakers are filled with paraffine, and heated to a desired point, then immersed in water at 15 deg. C. The temperature reached before fracture averages 253 deg. C. No data is given with

reference to beakers of foreign manufacture. Tests were also conducted in the way of resistance to fracture by dropping. The beakers are dropped from varying heights onto a 2-in. pine plank. The average height which these beakers withstood was 30.7 in. A large number did not break at 36 in., and were not carried further. These are tests which apparently are used to give a favorable comparison of American glassware against that of German make.

Still another manufacturer gives data on glass baking dishes which, to the writer's knowledge, were never imported from abroad. Therefore, the data are not exactly in order in this discussion.

Another manufacturer states that the element potassium has been eliminated from certain glasses resulting in the saving of a large amount of potassium carbonate, and that the glasses in many respects are superior to the old.

Another development is in optical glass. It is stated that a glass has been developed which is faintly yellowish in color and which absorbs all ultra violet rays and therefore is especially useful in the manufacture of glasses for electric furnace work.

Another manufacturer has stated that he has been able to manufacture a very limited line of glassware for laboratory use, but has been unable to extend his line on account of manufacturing conditions.

This testimony, both by the user and the manufacturer, seems to be overwhelmingly in favor of the conclusion that American made glassware can be secured which excels in numerous properties that which has been imported from abroad. The criticism in regard to price seems to me an improper one and the subject would be more properly discussed when competition again occurs.

Our next subject, and one which is of great importance, is that of chemical porcelain. Here we have again had much testimony, principally from the manufacturer. That there is a prejudice, however, may be seen in the statement of a prominent member of this society, as follows: "I certainly was surprised at the cracking of a small porcelain crucible I was heating. I could not find the crossed swords on the bottom. It probably would have had 'Made in America' on it if marked at all." By the testimony which follows, it would seem that even so high a recommendation as the crossed swords is not the *ne plus ultra* which this testifier would have us think. One man who states that he has used American made porcelain in four weeks of summer school, says that he has lost all idea of ever being able to secure good American porcelain. Turning from this pessimist for a moment, it is good to find such testimony, as the following:

Heating and cooling test, American-made porcelain against Royal Berlin, number cracked or crazed: In the case of Royal Berlin, one; American make, none. The test consisted in heating the sample to 1700 deg. Fahr. and then removing with a pair of steel tongs and tossing upon a steel plate in a draft. Next test, solubility in 25 per cent sodium hydroxide boiling for 6 hr.: American-made porcelain, 1.5 per cent; Royal Berlin, 1.8 per cent. Next test, effect of ferric oxide ignition or glaze: American make gained in weight, .001 per cent; Royal Berlin, .006 per cent.

Numerous other tests are reported, but comparison not being given, they are not quoted.

Certainly no pessimism is in order as the result of such tests. The greatest criticism that has been received on these articles is the long time it takes to secure them, and surely no one can say that this can refer to the quality of the articles. On the other hand, another user has stated that his bills for both glassware and porcelain have been cut in two by the use of American-made ware as compared to that of foreign made.

In the case of electrical instruments we believe that the situation has not changed since the war, as American-made instruments, by common consent, are the best in the world. Chemical balances are made with great success in this country; machinery used in the electrochemical industry has been nearly always secured here; microphotographic apparatus made here, it is stated, is far ahead of anything made in Europe. Articles like filter paper have been long made of high quality; microscopes of American manufacture cannot be beaten. Some other instruments which have been made abroad are being worked on now in this country.

A long and animated discussion followed. Mr. Hinckley discussed large carbon electrodes of American manufacture, Dr. Moore other carbon products (brushes, arc lamp carbons, etc.), and Mr. Beckman referred to the manufacture of arc lamp carbons on the Pacific Coast. Mr. Canby referred to the early production of pure nickel in this country, Mr. Scherl to American-made carbon brushes for electrical machinery.

Dr. Cushman emphasized that a sound judgment on the quality of a product can only be founded on the test of actual service, extending over years, and should not be based on specially devised short tests. Mr. Saunders said that he would not buy things on the manufacturer's reputation and that tests, even quickly made, were useful. Dr. Cushman replied he did not believe in the reputation of a manufacturer, but in the reputation of an article of established manufacture.

Mr. Colby spoke on platinum and emphasized that the production of any grade of platinum was not a question of ability of the American manufacturer. If the trade wants it, it can be had.

Mr. Saunders thought that in many complaints the real trouble was the short pocket-book of the college professor. If you are willing to pay the price, you can have what you want. Dr. Richards thought the problem was to get the same quality at the same price.

Messrs. Moore and M. B. Smith discussed American-made thermometers and the corrections necessary for the extent of stem immersion. Both agreed on the necessity of frequent calibrations.

Dr. Frary referred to the duty-free importations for universities as an important point in the problem. For the average class of students not exactly the same ware is needed as for an industrial laboratory.

Dr. Fink said the public had had a wrong impression as to the value of imported goods and said that the past few years had taught a valuable lesson. For instance, the value of American-made plate glass is now understood and appreciated.

Dr. Richards referred to the Guggenheim copper leaching plant in Chile, where magnetite electrodes are used. These were formerly imported from abroad, but now they make them themselves.

Dr. W. H. Walker thought that general hopefulness should prevail. We should give our manufacturers time and they will produce what we want.

Dr. Lyon said he had no trouble with getting American-made glassware and porcelain, but with filter paper. Dr. Richards said good filter paper was made in this country.

Mr. Acheson Smith emphasized that one of the main objects of the whole discussion was to bring manufacturer and consumer together.

Mr. Canby related an instance of co-operation between a Pueblo smelter and a Denver manufacturer of assaying apparatus which had produced great results.

The manufacture of graphite crucibles was also discussed and the necessity of blending American clays emphasized. Dr. Richards said the increase in the price of crucibles had greatly aided electric steel developments. Mr. Schramm thought many troubles with crucibles were due to improper handling. Mr. Smith thought that the shortage of stock had resulted in insufficient time being spent for annealing.

Thursday Afternoon and Friday Sessions

Limitations of space in the present issue force us to reserve accounts of the Thursday afternoon and Friday sessions for our next issue. The Thursday afternoon session was devoted to electrometallurgical papers and elicited some lively discussions on the non-corrosive properties of copper-steel versus pure iron and on various electroplating problems. In the Friday session the dry-cell and storage-battery papers were first presented. Dr. Hering's paper on high-temperature heat developed during electrolysis, elicited considerable discussion.

A smoker at the Hotel Astor on Thursday night was attended by between 800 and 900 chemists.

The convention is to be concluded on Saturday by a complimentary boat ride up the Hudson.

Can an American Potash Industry Be Established?

By Emil D. Koeppig

To live people must consume certain products of the soil, and are thus dependent on agriculture. Potash is one of the three vitally important plant foods. It is usually present in abundance in most soils, but only a small percentage of that present is in an available condition. The balance is bound up in silicates, from which it is released only by extremely slow natural processes. A considerable amount of the potash present in the available condition is removed with each crop, causing depletion of the soil. No one plant food can substitute for the lack of another, so it becomes necessary to artificially replenish the supply. That this is now being realized is demonstrated by the fact that of the total production of potash between 85 and 90 per cent is used in agriculture. The tonnages used have been increasing, and will doubtless continue from year to year along with the increasing enlightenment of the farmer along the lines of scientific agriculture.

Potassium salts are indispensable to many industries, as practically every present-day industrial activity requires potash in some form. Photographers, dyers, painters, and many cleaners, bleachers, weavers and soapmakers use it. It is used in refrigeration, in producing preservatives, fireworks, gunpowder, matches, paper, glass and aniline dyes.

The industries consume at the present time about 14,000 tons per year (basis K_2O), while for agricultural purposes about 216,000 long tons are used.

The sources of potash are wood ashes, tobacco stems, cottonseed husks, refuse of beet sugar manufacture and wool washing. The amount available from these sources is very small compared to the 230,000 or more long tons annually required, and the United States, like all other countries, is dependent on Germany for its supply of soluble potash salts.

Other than wood ashes and vegetable refuse there are four potential sources of potash in the United States: subterranean brines and salt lakes in the West, kelp, feldspar, and known deposits of the alunite type. In addition to these there is the possibility that the sinking of bore holes in districts of proper geologic formation would lead to the discovery of beds identical with or similar to the Stassfurt deposits of Germany.

KELP

The possibilities of utilizing the giant kelp groves of the Pacific Coast are interesting. That the potash, which is often as high as 30 per cent of the ash, contained in kelp can be recovered is certain. In fact, potash is and has been for a long time past produced in the vicinity of Glasgow, Scotland, from a similar seaweed. The quantity produced is small, amounting to about 2000 tons per years.

The first problem to be solved before kelp could be used on a large scale as a source of potash is the method of harvesting and handling the wet kelp. Considerable difference of opinion exists on the subject. Some investigators maintain that it is impossible to handle this material in a profitable way, while others are just as certain that the operation is satisfactorily solved. The weight of evidence appears to be with the latter.

Many ways of utilizing the values of the kelp have been proposed. One of the simplest is to dry and grind the kelp,¹ in which form it is in itself a good fertilizer, supplying nitrogen, phosphorus, and potash. The kelp

readily decomposes in the soil, which is an advantage, as it aids in increasing the humus material.

Most of the other processes suggested are ones which aim to produce technically pure potassium chloride.

Filtration processes applied to green kelp are failures, because the fiberless character of the organic matter causes clogging of the filters. A British patent² aims to overcome this difficulty by pulping and then forcing the pulp under pressure through a heater and heat recuperator at a temperature sufficiently high to destroy the slimy water binding character of the organic matter, namely, about 170 deg. C. The pulp is then cooled and pressed. The expressed liquid is used for the pulping of fresh material, thus increasing the potash concentration. Potassium chloride and iodine are the products from the expressed liquors. The residue after further pressing and drying out is used as a solid fuel or distilled to form a gaseous fuel, in which case the final charred residue is suitable for use as a filtering and clarifying agent.

Other processes recommend preliminary drying of the material. About the only way in which this could be satisfactorily accomplished is in a rotary dryer, as if the material is heated without stirring it matts down and potassium chloride may be volatilizing from the surface while the interior of the mass is still quite cool.³

S. R. Oppenheim⁴ proposes drying kelp for the recovery of potash and other values in the following manner: A direct flame is applied to a thick layer of kelp in a charring furnace to ignite it, and after a considerable portion of the kelp near the flame is in a glowing condition the flame is discontinued and a down draft maintained through the kelp until the whole layer is charred. The temperature of the furnace walls is maintained below 350 deg. C., and care is taken not to incinerate the mass.

Once the values are separated from the plant, however it be accomplished, it is relatively simple to separate the sodium and potassium chlorides from each other.

Assuming a satisfactory solution of the technical problems, there still remain certain economic problems to be considered, which make it doubtful if kelp will develop into a source of supply of a large amount of potassium salts.

SUBTERRANEAN BRINES AND SALT LAKES

Many brines from all parts of the United States have been investigated as to the possibility of thus establishing a potash supply. The results of this extensive survey have been greatly disappointing. Many of these brines were found to contain not inconsiderable percentages of potash, but the concentration of potash is so low in comparison to the other salts, and the combination of salts such that it is not likely that the extraction of potash from them will ever be commercially possible.⁵

The salts found in the Searles Lake basin in southeastern California are of a more promising character. The valley floor commonly known as Searles Lake has had a somewhat lengthy history. It was discovered by John W. Searles in 1862. At the time he was prospecting for gold and did not pay much attention to it. Later, when borax began to draw attention, he recognized the resemblance of some samples of this salt which were shown him to the materials he had seen while crossing the alkaline flat several years before. He, together with E. M. Skillings, located claims in

¹Brit. 1,766 Holberg, Testrup & Techno-Chem. Laboratories.

²F. K. Cameron, Chem. Eng. 22, 6.

³U. S. 1,111,482.

⁴J. W. Turrentine, U. S. Dept. Agric., Bur. Soils, Bull. #4.

⁵J. W. Turrentine, Am. Fert. 42, 37-42; also I. F. Laucks, Met. & Chem. Eng. 14,304.

February, 1873, on such portions of the marsh as he considered most valuable.

Whitman Symmes, in 1898, was the first to suggest that potash might become a profitable product of the deposit. It is said that at the time he located nearly the whole area with the object of working the underlying brine for borax, soda and potash. This enterprise lapsed for want of support.

In 1908 C. E. Dolbear located the whole deposit for the purpose of establishing there a soda ash industry. A plant was put in, but for some reason the whole equipment was allowed to become idle before any soda was shipped. The deposit again came into prominence in 1912, when the United States Geological Survey indicated it as a possible source of potash. Development work has been going on since that time. In April, 1915, the American Trona Corporation was actively engaged in constructing an experimental plant to handle 20,000 gal. of brine daily. It was expected at that time that the products would be on the market late in 1915, but so far as I know are not as yet being sold. However, delays in pioneering work of this character are to be expected.

A plant is also being constructed on the shores of Owen's Lake, California, for the production of potassium chloride. Owen's Lake is a shallow salt lake having an area of 97 square miles, as compared with 65 square miles for Searles Lake. However, the concentration of potash salts in Owen's Lake is very much lower than in Searles Lake.

It is reported⁴ that solid potassium bearing salts have been discovered in depth in Texas. It is stated that one well at a depth of 875-925 ft. contained 87.24 per cent of solid material of which 9.23 per cent was potash. Another well at a depth of 1700 ft. contained 51.72 per cent of soluble material, and of this 10.50 per cent was potash. It is stated that borings from two wells contained a salmon red substance which showed 14 per cent potassium chloride upon analysis and resembled carnallite. This occurred at a depth of 900 ft. in a bed of rock salt which overlies three other salt beds measuring together several hundred feet in thickness. Apparently, though, these deposits are small lenses, as the reported average for twenty-six samples taken at depths varying from 800-1700 ft. is only 0.44 per cent K₂O.

ALUNITE

Alunite, an insoluble double basic sulfate, occurs massive near Marysville, Piute County, Utah.

There are practically no technical difficulties involved in the production of potassium sulfate, impure alumina and sulfuric acid from this material. But there is no ready market for sulfuric acid in southern Utah in normal times, so it would be necessary to either allow the sulfur dioxide and trioxide gases to escape into the air or condense them and discharge them into the streams. If allowed to escape into the air they might damage vegetation, and this would probably bring objections from the Federal authorities as the deposits are located in a forest preserve. To condense the gases and discharge them into the streams would create a menace to fish life, and this would most certainly be objected to by the State authorities. There is no considerable market for impure alumina.

Though alum has been produced from alunite, the Roman alum being an example, pure potassium sulfate never was until two Utah companies, the Utah Potash Company and the Mineral Products Corporation, placed their product on the market in 1915, the latter in October of that year.

The production has not been large so far, owing to

the unforeseen incidents which usually turn up in work of this character. The product is a high-grade sulfate, and it is to be hoped that production increases, as this is the only naturally occurring source of sulfate of potassium now known in the United States.

The Bureau of Soils' reports that ignited alunite may be used directly as a fertilizer. The percentage of potassium oxide in it is greater than in kainit.

FELDSPAR

The first experimental work on the recovery of potash from feldspar was done by Tilghman in 1845, and the first United States patent was obtained by Bickel in 1856. Investigation of this field has been carried on ever since. The recent work has been, in a general way, along four lines: first, use of natural agents, such as heat, bacteria, carbon dioxide, etc.; second, wet chemical methods; third, dry volatilization reactions, and, fourth, dry heat reactions, by which the potash is rendered water soluble.

Franklin G. Carpenter⁵ proposes to render the potash in feldspar available for plant food by intensely heating the feldspar, suddenly chilling in water to reduce it to an amorphous state, and finally grinding.

H. W. Foote and S. R. Scholes⁶ decompose feldspar by heating it together with an equal quantity of sulfuric acid and one-tenth as much calcium fluoride as feldspar in sealed containers at a temperature of about 140-150 deg. C.

The product is then leached with water and potash alum is obtained from which potassium sulfate and alumina can be prepared. The reaction is stated to decompose 88.9 per cent of the rock.

E. E. Dougherty⁷ proceeds along somewhat similar lines. In working with leucite he adds sufficient sulfuric acid to combine with the bases, and after adding 2 per cent of the weight of the mixture of hydrochloric acid heats the whole until it becomes pasty and until the greater part of the water present has been driven off. The temperature is then raised to 500 deg. C. and the heating continued to drive off all the hydrochloric acid and the remaining water. The hydrochloric acid driven off is passed into a fresh charge, which has been mixed with sulfuric acid. The water soluble sulfates are then recovered from the residue by lixiviation.

Most of the processes designed to volatilize the potash from feldspar also aim to produce cement.

W. H. Ross⁸ states that if feldspar is heated in an open receptacle at about 1400 deg. C. with lime that practically all the potassium is volatilized, leaving a material resembling Portland cement closely in composition and suitable for use as a cement.

H. E. Brown⁹ produces potassium chloride and cement by fusing feldspar in an inert or oxidizing atmosphere at about 1300 deg. C. with sufficient calcium chloride to combine with all the potassium present and with sufficient calcium carbonate to bring the CaO content of the product up to about 50 per cent and collecting the volatilized potassium chloride.

He also patents¹⁰ a method of improving the cementing properties of the product, which consists in adding magnesium sulfate to the molten product.

Many other investigators proceed along the same lines, producing cement and either potassium chloride or oxide. These processes are hardly commercial possibilities, as any attempt to supply the country's needs would result in overloading an already well supplied cement market.

⁴U. S. Dept. Agric. Bur. Soils, Circ., 70.

⁵U. S. P. 959, 841.

⁶J. Ind. & Eng. Chem. A, 3, 377.

⁷U. S. P. 1, 148, 156.

⁸Orig. Comm. 8th Intern. Congr. Appl. Chem. 15, 217-29.

⁹U. S. P. 1, 123, 841.

¹⁰U. S. P. 1, 124, 238.

F. Thompson¹¹ patents a process of obtaining potassium sulfate from feldspar by mixing 5 parts of it with 5 parts of niter cake and 1.8 parts of salt. This mixture is then heated for one to two hours at a bright red heat, thereby partially fusing the mass. The product is then cooled, ground and leached with water. The sulfates of sodium and potassium thus extracted are then to be separated by fractional crystallization. The yield is stated to be 80-90 per cent.

E. Hart¹² proceeds in a somewhat different manner. He fuses one molecular proportion of feldspar with one molecular proportion of barium sulfate and two molecular proportions of carbon. The product of the fusion is then to be ground and the soluble constituents extracted by leaching with sulfuric acid. The same investigator describes another process,¹³ which is to fuse together feldspar, potassium sulfate and carbon in the molecular proportions of 4:4:2, a little excess of carbon being used. The product of fusion is to be finely ground, dissolved in dilute sulfuric acid leaving a residue of silica. The products are said to be (1) silica pure enough for use in pottery, (2) alumina, (3) potassium sulfate, and (4) a small quantity of potassium sodium carbonate used for making soft soap.

A. S. Cushman and G. W. Coggeshall¹⁴ have carried on experiments with their process on a semi-commercial scale and effect a recovery of about 75-80 per cent of the potash in the feldspar treated. The final product is an 80 per cent muriate. Briefly their process is as follows: One hundred parts of ground feldspar is mixed with 20 parts of lime. This mixture is then fed into a rotary mixer and is sprayed with calcium chloride solution. The calcium oxychloride formed causes the formation of "clumps" or aggregates about the size of a pea. These "clumps" are then passed through a rotary kiln heated to 1050-1150 deg. C. The burned "clumps" are then extracted with water, a 10 per cent solution of potassium chloride resulting. This is concentrated with flue gases to 80 per cent potassium chloride crystals. The process is continuous.

The engineering details of this process have been quite thoroughly worked out, and it is estimated that 80 per cent muriate can be produced by it at a cost of \$31.32 per ton. This figure allows a 20 per cent profit, based on the ante bellum prices of muriate. An outlet for the mineral by-product at a very nominal figure would materially reduce the cost of production of the potassium chloride.

A. H. Cowles¹⁵ renders the potash in feldspar available for plant food in a wholly different manner. His process is to heat phosphate rock and potash feldspar to the sintering temperature or higher. The proportions of phosphate rock and feldspar are adjusted so that the CaO and SiO₂ shall be in the molecular proportions of 2 and 1 respectively. The sintered product is then treated with sulfuric acid. The result being a fertilizer containing available potash and phosphorus.

C. W. Drury¹⁶ prepares a fertilizer from feldspar by heating it with lime and iron oxides at a high temperature. A somewhat similar process has been tried in Sweden.¹⁷ The feldspar is mixed with coal and iron filings and heated in an electric furnace. The products are ferrosilicon and slag. The slag contains the potash in a more soluble form than the raw material. It is sold under the name of "electrokali." Field experiments carried out with this "electrokali" gave results equal to 78 per cent of the yields given by sulfate of potash.

So it would seem that an American potash industry on a large scale can be established. That it has not come into being is no doubt due to the fear of having to meet a cut in prices by the German producers, which it would hardly be able, in the present status of the art, to survive. Possibly in the future a process will be developed which will be able to meet any competition. When such a process becomes a reality we may look for the beginning of a great American potash industry.

Lockport, N. Y.

The Thermal and Pressure Decomposition of a Naphthene Base Oil in the Gas Phase

By Gustav Egloff, Thomas J. Twomey and Robert J. Moore

In the thermal and pressure decomposition of hydrocarbon oils in the gas phase, a general study¹ of the types of oils has been undertaken with a view to ascertaining the general direction of the reaction and to study the relative importance of the starting oils as to the formation of gasoline, unsaturated and aromatic hydrocarbons. The present communication covers the effect of temperature and pressure upon naphthene base oils in the formation of gasoline, unsaturated and aromatic hydrocarbons.

Scope of the Investigation

The two oils investigated were of naphthenic character, derived from two different oil fields and were studied with a view to determining the value of the oils and to further emphasize the importance of the character of the starting oil for the production of gasoline and the aromatic hydrocarbons, benzene, toluene and xylene and also the amount of unsaturation in the distillation cuts. The two oils were subjected to the same conditions of temperature and pressure in the gas phase. After treatment, the oils recovered were analyzed by distillation, specific gravity, sulphonation for unsaturation, and the aromatic hydrocarbons, benzene, toluene and xylenes were determined as the nitro derivatives.

The Type of Oils Used

The naphthene base oils used were derived from two different oil fields, and represented in the one case 24

¹Rittman and Egloff, Met. and Chem. Eng., 14, 70, 1915. Egloff and Twomey, Jour. Phys. Chem., 20, 121, 1916. Ibid., 20, 515, 1916. Egloff, Met. and Chem. Eng., 15, 125, 1918. Egloff and Twomey, Met. and Chem. Eng., 15, 245, 1916. Egloff, Twomey and Moore, Jour. Ind. Eng. Chem., 8, Oct. 1, 1916. Ibid., Jour. Phys. Chem., 20, Oct., 1916.

TABLE I.—THE PERCENTAGES OF RECOVERED OIL AND THE SPECIFIC GRAVITY OF THE RECOVERED OIL AT TEMPERATURES 550 DEG., 600 DEG., AND 700 DEG. C. AT ONE AND EIGHTEEN ATMOSPHERES PRESSURE

OIL No. 1				
ONE ATMOSPHERE PRESSURE				
Temperature, deg. C.	550	600	650	700
Per cent recovered oil	90.0	78.0	59.5	52.5
Specific gravity	0.843	0.843	0.853	0.891
EIGHTEEN ATMOSPHERES PRESSURE				
Per cent recovered oil	67.3	54.7	38.6	32.0
Specific gravity	0.892	0.870	0.918	0.955
OIL No. 2				
ONE ATMOSPHERE PRESSURE				
Temperature, deg. C.	550	600	650	700
Per cent recovered oil	90.0	72.0	56.1	41.1
Specific gravity	0.848	0.850	0.874	0.939
EIGHTEEN ATMOSPHERES PRESSURE				
Per cent recovered oil	83.7	65.8	47.1	30.7
Specific gravity	0.840	0.874	0.951	0.978

¹¹U. S. P. 995, 165.

¹²U. S. P. 997, 577.

¹³Trans. Amer. Ceram. Soc. 13, 683-8.

¹⁴J. Ind. & Eng. Chem., 7, 2, p. 115.

¹⁵U. S. P. 1, 126, 408.

¹⁶Canadian Pat. 160, 257.

¹⁷Chem. Eng., 20, 3, p. 130.

per cent of the original crude oil and in the other 11 per cent. Twenty-five gallons of each oil was distilled with steam and direct heating until the oil, which we will for sake of convenience call number one, gave a distillate of 24 per cent. The other oil, we will designate as oil number two. Twenty-five gallons of this oil were distilled under the same conditions until 11 per cent came over. The residues of 76 and 89 per cent were valuable lubricating oils, and were utilized for that purpose. The oils number one and two, which were subjected to temperatures 550 deg., 600 deg., 650 deg. and 700 deg. C. at pressures of one and eleven atmospheres, analyzed before treatment as follows:

DISTILLATION ANALYSIS			
Oil	No. 1	No. 2	
Specific gravity.	0.843	0.847	
Temperature, Deg. C.	Per Cent by Volume		
To 150	1.3	0.0	
150 to 200	26.0	22.0	
200 to 250	32.7	44.0	
250 to 300	27.5	25.0	
300 to 335	5.6	6.0	
Residue	6.8	3.0	
SPECIFIC GRAVITY			
To 150	0.838	0.832	
150 to 200	0.846	0.844	
200 to 250	0.850	0.853	

Experimental Procedure

The experimental procedure consisted of passing a definite volume of the naphthene base oil through an electrically heated steel tube at a carefully regulated rate of oil flow.² The starting oil was filtered before use and in each experiment 700 c.c. of oil were used. After subjecting the oil to different conditions of temperature and pressure the cracked oil was collected from the receiver, filtered free from carbon and the volume of the recovered oil noted. The pressure of eleven atmospheres used was built up by means of a compressor, using natural gas. The pressure after building up to

²Egloff and Twomey, Jour. Phys. Chem., 20, 121, 1916.

TABLE II—THE DISTILLATION CUTS OF THE RECOVERED OILS

OIL No. 1				
ONE ATMOSPHERE PRESSURE				
Temperature, deg. C.	550	600	650	700
Per Cent by Volume				
To 95	3.6	6.6	9.7	10.9
95 to 120	3.9	5.2	9.7	8.4
120 to 150	10.1	12.5	13.1	13.6
150 to 175	6.7	12.3	9.5	10.7
175 to 230	30.5	22.4	32.4	28.4
230 to 270	26.1	11.4	12.5	6.3
270 to Pitch	9.9	5.7	6.3	5.5
Pitch	8.3	23.8	5.9	16.1
ELEVEN ATMOSPHERES PRESSURE				
Temperature, deg. C.	550	600	650	700
Per Cent by Volume				
To 95	7.8	12.0	13.5	16.5
95 to 120	8.1	11.8	15.6	16.1
120 to 150	14.2	17.0	13.9	11.4
150 to 175	13.4	12.1	7.6	3.9
175 to 230	24.1	20.5		
230 to 270	13.1	11.9		
270 to Pitch	6.1	4.7		
Pitch	8.7	9.9		
OIL No. 2				
ONE ATMOSPHERE PRESSURE				
Temperature, deg. C.	550	600	650	700
Per Cent by Volume				
To 95	1.6	6.4	9.5	12.1
95 to 120	1.8	4.9	8.8	11.0
120 to 150	2.4	6.1	7.5	10.8
150 to 175	5.6	11.8	11.8	10.6
175 to 230	23.9	25.9	18.1	
230 to 270	23.6		12.2	
270 to Pitch	4.5		8.2	
Pitch	11.5		11.4	
ELEVEN ATMOSPHERES PRESSURE				
Temperature, deg. C.	550	600	650	700
Per Cent by Volume				
To 95	5.1	9.6	17.7	22.3
95 to 120	4.8	11.3	12.4	10.8
120 to 150	7.0	10.5	10.9	7.5
150 to 175	12.7	10.1	6.6	6.6
175 to 230	28.2	22.1	13.6	10.5
230 to 270	24.3	19.3	8.7	9.5
270 to Pitch	8.7	4.2	5.3	9.2
Pitch	7.0	9.7	25.1	23.6

the required atmospheres was shut off and was further maintained in the system by means of the decomposition products of the oil.

The temperatures to which the naphthene base oil was subjected were 550 deg., 600 deg., 650 deg. and 700 deg. C. and two pressures of one and eleven atmospheres were used. The cracked oil was analyzed for its gasoline, unsaturation content and the aromatic hydrocarbons, benzene, toluene and xylene by means of the following tests:

1. Distillation of liquid reaction products by means of a Ginsky distilling head.
2. Specific gravity of the liquid reaction products by means of a Westphal balance at 15.5 deg. C.
3. The gasoline content was determined by means of distillation, specific gravity and unsaturation.
4. The unsaturation³ was determined by means of

³Egloff and Twomey, Met. and Chem. Eng., 15, 247, 1916.

TABLE III—THE COMPARISON OF THE SPECIFIC GRAVITY OF THE DISTILLATION CUTS OF THE RECOVERED OILS

OIL No. 1				
ONE ATMOSPHERE PRESSURE				
Temperature, deg. C.	550	600	650	700
Specific Gravity				
To 95	0.732	0.753	0.791	0.829
95 to 120	0.800	0.815	0.844	0.858
120 to 150	0.829	0.836	0.855	0.860
150 to 175	0.840	0.845	0.862	0.871
175 to 230	0.852	0.858	0.882	0.900
230 to 270	0.858	0.864	0.905	0.921
270 to Pitch	0.863	0.899	0.932	0.932
ELEVEN ATMOSPHERES PRESSURE				
Temperature, deg. C.	550	600	650	700
Specific Gravity				
To 95	0.746	0.786	0.856	0.871
95 to 120	0.825	0.851	0.867	0.869
120 to 150	0.845	0.857	0.867	0.869
150 to 175	0.848	0.863		
175 to 230	0.873	0.894		
230 to 270	0.893	0.925		
270 to Pitch	0.906	0.945		
OIL No. 2				
ONE ATMOSPHERE PRESSURE				
Temperature, deg. C.	550	600	650	700
Specific Gravity				
To 95	0.770	0.749	0.798	0.854
95 to 120	0.815	0.815	0.842	0.867
120 to 150	0.824	0.827	0.849	0.872
150 to 175	0.839	0.848	0.867	0.879
175 to 230	0.860	0.860	0.933	
230 to 270	0.873	0.873	0.976	
270 to Pitch	0.905	0.905	0.998	
ELEVEN ATMOSPHERES PRESSURE				
Temperature, deg. C.	550	600	650	700
Specific Gravity				
To 95	0.734	0.773	0.865	0.873
95 to 120	0.804	0.848	0.870	0.870
120 to 150	0.823	0.856	0.869	0.870
150 to 175	0.845	0.867	0.876	0.879
175 to 230	0.855	0.890	0.945	Naphthalene
230 to 270	0.866	0.928	0.984	Naphthalene
270 to Pitch	0.883	0.970	0.998	Anthracene

TABLE IV—THE PERCENTAGES OF OLEFINS IN THE DISTILLATION CUTS

OIL No. 1				
ONE ATMOSPHERE PRESSURE				
Temperature, deg. C.	550	600	650	700
Per Cent by Volume				
To 95	35	50	46	31
95 to 120	29	31	40	15
120 to 150	22	30	40	12
150 to 175	25	52	35	
ELEVEN ATMOSPHERES PRESSURE				
Temperature, deg. C.	550	600	650	700
Per Cent by Volume				
To 95	47	54	51	36
95 to 120	34	31	24	10
120 to 150	30	19	17	
150 to 175	20	14	22	16
OIL No. 2				
ONE ATMOSPHERE PRESSURE				
Temperature, deg. C.	550	600	650	700
Per Cent by Volume				
To 95	47	54	51	36
95 to 120	34	31	24	10
120 to 150	30	19	17	
150 to 175	20	14	22	16
ELEVEN ATMOSPHERES PRESSURE				
Temperature, deg. C.	550	600	650	700
Per Cent by Volume				
To 95	45	41	10.5	12
95 to 120	32	32	4.5	7
120 to 150	21	11	6.5	8
150 to 175	20	20		

1.84 specific gravity C. P. sulphuric acid, Babcock, test bottles and centrifuge.

5. The percentage of benzene, toluene and xylene was determined by means of distillation, specific gravity and nitration.

A. THE EFFECT OF TEMPERATURE AND PRESSURE ON THE PER CENT OF RECOVERED OIL AND THE SPECIFIC GRAVITY OF THE RECOVERED OIL AT TEMPERATURES 550 DEG., 600 DEG., 650 DEG. AND 700 DEG. C., AT ONE AND ELEVEN ATMOSPHERES PRESSURE

The percentage of recovered oil from oil number one for both pressures used showed a marked decrease with increase in cracking temperature. At atmospheric pressure the amounts recovered ranged from 90 per cent at 550 deg. to 52.5 per cent at 700 deg. C.; while at eleven atmospheres pressure the same temperatures showed a range of 67.3 to 32.0 per cent respectively.

This decrease in amount recovered with increase in temperature is to be expected, considering the greater decomposition taking place at the higher temperatures, the tendency being to go completely to carbon and hydrogen as the temperature increases.

The amount of decomposition is further manifested by the specific gravities of the recovered oils which, for both pressures used, gave higher values with increased cracking temperatures.

At 550 deg. and atmospheric pressure, where 90 per cent were recovered, the specific gravity, 0.843, was identical with that of the starting oil, while at 700 deg.

where only 52.5 per cent were recovered, the specific gravity showed the maximum of 0.894.

For the same temperature of cracking, the increased-pressure runs in each case yielded lower percentages of recovery than the run at atmospheric pressure. And the recovered oil from the pressure runs showed for each temperature a much higher specific gravity than the recovered atmospheric-pressure oils.

Oil number two under the same conditions of temperature and pressure gave percents of recovery uniformly higher, with one exception, at 700 deg. C. and eleven atmospheres. The specific gravity showed results somewhat similar. All hydrocarbon oils would tend to converge to the same percentage of recovered oil, as the temperature of decomposition tends toward the formation of the ultimate products, carbon and hydrogen.

B. THE DISTILLATION CUTS OF THE RECOVERED OILS

The most striking difference shown by both oils used in the comparison of one atmosphere and eleven atmospheres is the larger percentage distilling below 150 deg. C. in each case from the runs at eleven atmospheres pressure.

For the runs at atmospheric pressure the fractions below 150 deg. C. yield, with one exception, larger percentages with increased temperature of the cracking process.

Under eleven atmospheres pressure the cuts to 150 deg. C. increased with higher cracking temperature from 30.4 per cent at 550 deg. to 44.3 per cent at 700 deg. C.

The cuts above 150 deg. C., however, yielded uniformly lower percentages with increasing temperature, while the pitch made up the difference by increasing in general with increased temperature.

The same tendency of lower boiling-point hydrocarbon formation is shown by both oils, with increase of temperature and pressure.

C. THE COMPARISON OF THE SPECIFIC GRAVITY OF THE DISTILLATION CUTS OF THE RECOVERED OILS

One of the most significant facts to be noticed in comparing these figures is that in every case the specific gravity of the distillation cuts from the eleven-atmospheres-pressure runs is higher than the specific gravity of the corresponding cut of the atmospheric-pressure runs, using oil number one. This would indicate a greater formation of lower boiling-point paraffin hydrocarbons at atmospheric pressure with higher aromatic formation as the pressure is increased to eleven atmospheres.

Increase of cracking temperature at both pressures used yielded uniformly oils of higher specific gravity, while in each case the specific gravity of high-pressure run was higher than that of the corresponding cut of the atmospheric-pressure run.

TABLE V—THE PERCENTAGES OF BENZENE, TOLUENE AND XYLENE IN THE RECOVERED OIL

OIL No. 1				
ONE ATMOSPHERE PRESSURE				
Temperature, deg. C.	550	600	650	700
Per Cent by Volume				
Benzene.....	0.3	1.4	4.3	7.5
Toluene.....	2.0	3.0	7.9	6.7
Xylene.....	6.3	8.6	11.4	12.3*
ELEVEN ATMOSPHERES PRESSURE				
Benzene.....	1.3	4.9	11.5	15.6
Toluene.....	5.7	10.0	15.6	19.1
Xylene.....	11.0	14.8	13.6	11.2
*Probably experimental error.				
OIL No. 2				
ONE ATMOSPHERE PRESSURE				
Temperature, deg. C.	550	600	650	700
Per Cent by Volume				
Benzene.....	1.0	1.2	4.7	10.2
Toluene.....	2.2	3.0	7.1	10.8
Xylene.....	2.6	3.7	6.1	4.8
ELEVEN ATMOSPHERES PRESSURE				
Benzene.....	0.5	3.2	16.2	21.3
Toluene.....	2.5	9.5	12.5	10.8
Xylene.....	4.0	9.2	10.8	7.5

TABLE VI—THE PERCENTAGES OF BENZENE, TOLUENE AND XYLENE ON BASIS OF OIL USED

OIL No. 1				
ONE ATMOSPHERE PRESSURE				
Temperature, deg. C.	550	600	650	700
Per Cent by Volume				
Benzene.....	0.2	1.1	2.6	3.9
Toluene.....	1.8	2.3	4.7	2.5
Xylene.....	5.7	6.7	6.8	6.5
ELEVEN ATMOSPHERES PRESSURE				
Benzene.....	0.9	2.7	4.4	5.0
Toluene.....	3.8	5.5	6.0	5.2
Xylene.....	7.4	8.1	5.3	3.6
OIL No. 2				
ONE ATMOSPHERE PRESSURE				
Temperature, deg. C.	550	600	650	700
Per Cent by Volume				
Benzene.....	0.9	0.9	2.6	4.2
Toluene.....	2.0	2.2	4.0	4.5
Xylene.....	2.3	2.7	3.4	2.0
ELEVEN ATMOSPHERES PRESSURE				
Benzene.....	0.4	2.0	7.2	6.5
Toluene.....	2.1	6.1	5.9	3.3
Xylene.....	3.3	5.9	5.1	2.3

TABLE VII—THE PERCENTAGES OF GASOLINE IN THE RECOVERED OIL

OIL No. 1				
ONE ATMOSPHERE PRESSURE				
Temperature, deg. C.	550	600	650	700
Per Cent by Volume				
Per cent gasoline.....	17.6	24.3	32.5	32.9
ELEVEN ATMOSPHERES PRESSURE				
Per cent gasoline.....	30.4	40.8	43.0	44.3
OIL No. 2				
ONE ATMOSPHERE PRESSURE				
Temperature, deg. C.	550	600	650	700
Per Cent by Volume				
Per cent gasoline.....	5.8	16.4	25.8	33.9
ELEVEN ATMOSPHERES PRESSURE				
Per cent gasoline.....	17.2	31.4	41.1	40.6

With one exception oil number two indicated the same general characteristics of increase of specific gravity of the distillation cuts with increase of pressure. The exception noted was at temperature 550 deg. C.

From table V it can be seen that this fraction is exceptional in giving a lower percentage of benzene than the atmospheric-pressure run. This would account for the lower specific gravity.

D. THE PERCENTAGES OF OLEFINS IN THE DISTILLATION CUTS

The percentage of olefins present in the benzene cut (to 95 deg. C.), the toluene cut (95 deg. to 120 deg. C.), the xylene cut (120 deg. to 150 deg. C.), and the methylbenzene cut (150 deg. to 175 deg. C.), in conjunction with the specific gravity value, gives a criterion upon which to judge the amount of treatment necessary to obtain products free from unsaturation. The olefins are readily removed by concentrated sulphuric acid, esterification, addition of the halogen acids or halogens themselves, or by hydrogenation.

In the benzene cut in both oils the olefin content reaches a maximum and then decreases with increase of temperature at one atmosphere pressure; while at a pressure of eleven atmospheres the percentage of olefins decreases with increase of temperature.

The percentage of olefins in the toluene cut increases to a maximum in both oils and then decreases as the temperature increases, but with increase of pressure under the same conditions of temperature there is a sudden drop in the per cent of olefins between 600 deg. and 650 deg. C., which seems to be a critical temperature range for olefin formation under a pressure of eleven atmospheres with these two oils.

At atmospheric pressure the xylene and trimethylbenzene cuts exhibit the same tendency to olefin formation as the benzene and toluene cuts. At a pressure of eleven atmospheres the percentage of olefins in the cuts, xylene and trimethylbenzene decreases with increase of temperature.

In general it is to be noted that the greatest percentage of olefin formation occurs in the benzene cut; and decreases gradually in the toluene and xylene cuts. The trimethylbenzene cut, however, showed with three exceptions, an increase in the percentage of olefins present. The various theoretical views and experimental work as to the mechanism of the olefin reaction has been taken up by the subjoined list of workers.* No clear-cut experimental evidence, however, has as yet been brought forward by the experimenters in the field of hydrocarbons to settle the question.

E. THE PERCENTAGE OF BENZENE, TOLUENE AND XYLENE IN THE RECOVERED OIL

The percentage of benzene increased in both oils with increase of temperature and pressure. The maximum formation in oil number one being 15.6 per cent and in oil number two 21.3 per cent, both at 700 deg. C.

and eleven atmospheres as the working pressure.

In all cases except one, under the same temperature conditions an increase to eleven atmospheres pressure increased the formation of benzene in the recovered oils.

At 650 deg. C. and one atmosphere in oil number one and in oil two at the same temperature and eleven atmospheres, the formation of toluene reached a maximum in two cases.

The percentage of xylene in the recovered oil increased to a maximum in three cases and then decreased.

The following figures bring out forcibly the wide differences in the total per cent of benzene, toluene and xylene resulting under the same conditions of temperature and pressure from the two starting oils.

THE TOTAL PER CENTS OF THE AROMATIC HYDROCARBONS BENZENE, TOLUENE AND XYLENE IN THE RECOVERED OIL

Temperature, deg. C.	ONE ATMOSPHERE PRESSURE			
	550	600	650	700
	Per Cent by Volume			
Oil No. 1	8.6	13.0	23.6	26.5
Oil No. 2	5.8	7.9	17.9	25.8
	ELEVEN ATMOSPHERES PRESSURE			
Oil No. 1	18.0	29.7	40.7	42.9
Oil No. 2	7.0	21.9	39.5	39.6

This again emphasizes the great importance of the constituents of the starting oil in the thermal and pressure decomposition for the formation of benzene, toluene and xylene.

F. THE PERCENTAGES OF BENZENE, TOLUENE AND XYLENE ON BASIS OF OIL USED

The two naphthene base oils used in these experiments have yielded higher percentage formation of the aromatic hydrocarbons benzene, toluene and xylene upon the basis of oil used for production, than any other

TABLE VIII—THE PERCENTAGES OF GASOLINE ON BASIS OF OIL USED AND THE SPECIFIC GRAVITY OF THE GASOLINE

Temperature, deg. C.	OIL No. 1			
	ONE ATMOSPHERE PRESSURE			
	550	600	650	700
	Per Cent by Volume			
Per cent gasoline	15.8	18.9	19.3	17.2
Specific gravity	0.800	0.809	0.817	0.839
	ELEVEN ATMOSPHERES PRESSURE			
Per cent gasoline	20.4	26.2	16.7	14.2
Specific gravity	0.814	0.833	0.863	0.870
Temperature, deg. C.	OIL No. 2			
	ONE ATMOSPHERE PRESSURE			
	550	600	650	700
	Per Cent by Volume			
Per cent gasoline	5.3	11.8	14.5	15.0
Specific gravity	0.806	0.810	0.815	0.860
	ELEVEN ATMOSPHERES PRESSURE			
Per cent gasoline	11.4	24.1	19.5	12.4
Specific gravity	0.811	0.825	0.869	0.870

TABLE IX—THE PERCENTAGES OF OLEFINS IN THE GASOLINE CUT

Temperature, deg. C.	OIL No. 1			
	ONE ATMOSPHERE PRESSURE			
	550	600	650	700
	Per Cent by Volume			
Per cent olefins	28.0	37.5	42.3	18.6
	ELEVEN ATMOSPHERES PRESSURE			
Per cent olefins	35.2	28.1	10.3	8.2
Temperature, deg. C.	OIL No. 2			
	ONE ATMOSPHERE PRESSURE			
	550	600	650	700
	Per Cent by Volume			
Per cent olefins	35.9	35.4	34.2	19.3
	ELEVEN ATMOSPHERES PRESSURE			
Per cent olefins	32.0	27.6	8.6	12.3

*Wohl, Dinglers Polytech. Jour., 177, 69.
 Thorpe and Young, Proc. Royal Soc., 21, 184. Liebig's Ann., 165, 28. Chem. News, 23, 174, 1871.
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 Burgess and Wheeler, Jour. Chem. Soc., 105, 131, 1914.
 Elgloff and Twomey, Met. and Chem. Eng., 14, 247, 1916.

petroleum oil as far as the authors' experience is concerned or from values which are found recorded in the literature.

Since the naphthene series hydrocarbons are saturated polymethylenes these experiments lend added evidence to the general theory that one of the methods of aromatic hydrocarbon formation from petroleum oils is by dehydrogenation of naphthenes.

The data show the course of the reaction in the formation of dimethylbenzene or xylene, methylbenzene or toluene and benzene. The evidence is quite clear that the higher methyl derivatives of benzene form first and then decompose to lower methyl derivatives and then to benzene.

Other experimental work¹ has shown that benzene decomposes to diphenyl, to naphthalene, to anthracene, and finally to carbon and hydrogen.

The data in Table VI for both oils used show maximum formation of xylenes as follows: at atmospheric pressure maximum formation of xylene occurs at the temperature of 650 deg. C., oil number one yielding 6.8 per cent and oil number two 3.4 per cent. At eleven atmospheres pressure, however, both maxima occur at 600 deg. C., oil number one giving 8.1 per cent and oil number two 5.9 per cent.

Coincident with increase of xylene formation, toluene and benzene increase, but not so rapidly until the xylene maximum is approached. Here xylene falls off and toluene and benzene form at the expense of it until toluene reaches its maximum. Here the benzene forming at the expense of toluene approaches its maximum. The maximum formation of xylene, 5.9 per cent, was at eleven atmospheres and 600 deg. C.; for toluene

at the same temperature 6.1 per cent and for benzene 7.2 per cent at 700 deg. C.

The evidence is unmistakable from this and other work² of the thermal and pressure decomposition of pure aromatics that the course of reaction in aromatic hydrocarbon formation is as follows: Higher methyl derivatives of benzene as xylene to lower methyl derivatives of benzene, as toluene to benzene, and from other experimental work, benzene to diphenyl, to naphthalene, to anthracene, to carbon, and finally hydrogen.

Oils number one and two will give for every 100 gal. of oil thermalized under maximum-formation conditions the following percentages of aromatics:

OIL No. 1				
Per Cent by Volume	Benzene	Toluene	Xylene	Total per Cent Aromatic Hydrocarbons
One atmosphere and 650 deg. C.	2.6	4.7	6.8	14.1
Eleven atmospheres and 600 deg. C.	2.7	5.5	8.1	16.3
OIL No. 2				
Per Cent by Volume	Benzene	Toluene	Xylene	Total per Cent Aromatic Hydrocarbons
One atmosphere and 700 deg. C.	4.2	4.5	2.0	10.7
Eleven atmospheres and 650 deg. C.	7.2	5.9	5.1	18.2

The data just preceding again emphasizes the high importance of the starting oils in thermal and pressure decomposition. Although the distillation analysis and specific gravity values of the two starting oils are quite similar, yet upon subjection to the same temperature and pressure conditions they give widely different yields of products.

The statement so frequently made in oil cracking circles that the starting oil is immaterial and that the temperature of reaction is of primary importance is not valid, since all the evidence at hand upon the thermal decomposition of hydrocarbon oils indicates clearly, as do the present data, that the starting oil is of high significance in such work.

G. THE PERCENTAGE OF GASOLINE IN THE RECOVERED OIL

Gasoline formation in the recovered oil at atmospheric pressure increased with increase of temperature from 17.6 per cent at 550 deg. to 32.9 per cent at 700 deg. C. in oil one, while under the same conditions oil two gave with one exception, much lower percentages, these ranging between 5.8 and 33.9, the latter per cent being the exception cited.

Increase of pressure had a great effect upon the gasoline formation in increasing the yields in every case, in one instance almost 300 per cent.

In oil one the per cent of gasoline at eleven atmospheres ranged between 30.4 and 44.3; while oil two under the same conditions gave a percentage yield between 17.2 and 41.1.

Upon the basis of gasoline formation in the recovered oil, oil number one gave uniformly higher per cents than oil number two, with a single exception. This exception was at 700 deg. C. and atmospheric pressure where oil number one gave 32.9 per cent gasoline and oil number two gave 33.9 per cent.

H. THE PERCENTAGE OF GASOLINE ON BASIS OF OIL USED AND THE SPECIFIC GRAVITY OF THE GASOLINE

Upon the basis of oil used for production the percentage of gasoline formation for oil one at atmospheric pressure gave values ranging between 15.3 and 19.3, while oil number two under similar conditions of temperature and pressure gave percentages of 5.3 to 15.0. It can be readily seen that oil number one gave a yield of

¹Berthelot, Zeit. Chem., 707, 1866.

Schultz, Liebig Ann., 174, 201, 1874. Ber., 9, 547, 1876.

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Smith Ber., 12, 722, 1879.

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Rittman, Byron and Egloff, Jour. Ind. Eng. Chem., 7, 1019, 1915.

Hollings and Cobb, Gas World, 60, 879, 1914.

TABLE X—THE PERCENTAGES OF OLEFINS ON BASIS OF OIL USED FOR PRODUCTION

OIL No. 1				
ONE ATMOSPHERE PRESSURE				
Temperature, deg. C.	550	600	650	700
Per Cent by Volume				
Per cent olefins	1.3	6.8	8.1	3.2
ELEVEN ATMOSPHERES PRESSURE				
Per cent olefins	6.9	6.0	1.6	1.1
OIL No. 2				
ONE ATMOSPHERE PRESSURE				
Temperature, deg. C.	550	600	650	700
Per Cent by Volume				
Per cent olefins	1.9	4.2	4.5	2.3
ELEVEN ATMOSPHERES PRESSURE				
Per cent olefins	5.4	5.5	1.7	1.5

TABLE XI—THE PERCENTAGES OF THE STARTING OIL, DECOMPOSED TO FORM CARBON AND GAS

OIL No. 1				
ONE ATMOSPHERE PRESSURE				
Temperature, deg. C.	550	600	650	700
Per cent carbon and gas	10.0	22.0	40.5	47.5
ELEVEN ATMOSPHERES PRESSURE				
Per cent carbon and gas	32.7	45.3	61.4	68.0
OIL No. 2				
ONE ATMOSPHERE PRESSURE				
Temperature, deg. C.	550	600	650	700
Per cent carbon and gas	10.0	28.0	43.9	58.7
ELEVEN ATMOSPHERES PRESSURE				
Per cent carbon and gas	16.3	36.2	52.5	69.3

²Rittman, Byron and Egloff, Jour. Ind. Eng. Chem., 7, 1019, 1915.

gasoline as much as 300 per cent greater than oil two. Moreover the specific gravity of the gasoline cuts of oil one gave values between 0.800 and 0.839; while oil two ranged between 0.806 and 0.860.

When the pressure was increased to eleven atmospheres under the same temperature conditions, the percentage of gasoline formation increased greatly. The maximum was found to occur in oil one at 26.2 per cent and specific gravity 0.833, while the maximum for oil two gave 20.1 per cent and specific gravity of 0.825.

Pressure not alone increased the gasoline formation but also the specific gravity of the gasoline fraction, this being primarily due to the increased aromatic formation.

The gasoline cut contained unsaturated hydrocarbons which were readily removed by sulphuric acid treatment, giving a clear water-white oil with aromatic odor and upon standing no deposition of resinous material.

I. THE PERCENTAGE OF OLEFINS IN THE GASOLINE CUT

In oil one the percentage of olefins in the gasoline cut to 150 deg. C. increased to a maximum of 42.3 per cent at one atmosphere and 650 deg. C.

With increase of pressure to eleven atmospheres the percentage of olefins decreased with increase of temperature, the percentages ranging between 35.1 and 8.2.

Oil number two gave a lower average per cent of unsaturated compound formation. The maximum of 35.9 per cent formation of unsaturated hydrocarbons occurred at atmospheric pressure and 550 deg. C. and the minimum of 8.6 per cent at 650 deg. C. and eleven atmospheres.

J. THE PERCENTAGE OF OLEFINS ON BASIS OF OIL USED FOR PRODUCTION

The effect of temperature upon the formation of unsaturated hydrocarbons in oil one at atmospheric pressure was to increase the percentage of unsaturated on the basis of oil used to a maximum of 8.1 as the temperature increased from 550 deg. to 650 deg. C.

The maximum in oil two occurred at the same temperature, giving a value of 4.5 per cent.

The minima for this oil gave 1.9 and 2.3 per cents, while oil one gave minima under the same conditions of thermolization of 4.3 and 3.2 per cents.

The effect of pressure upon the unsaturated hydrocarbon content of the oils upon basis of oil used for production is not so great as that of temperature, although in general, from the data, an increase of pressure decreases the unsaturated hydrocarbon formation.

But the pressure at lower temperatures increases the unsaturation formation.

This is not a general phenomenon, for in most of the recorded data upon the effect of pressure upon decomposition of hydrocarbon oils the effect seems to decrease the formation of unsaturated hydrocarbons.¹

Oil number one evidenced a greater tendency toward the formation of hydrocarbons absorbed by sulphuric acid than oil two. Under the same conditions of temperature and pressure oil one gave as high as 225 per cent greater yield of unsaturated hydrocarbons than oil two.

K. THE PERCENTAGE OF THE STARTING OIL DECOMPOSED TO FORM CARBON AND GAS

The thermal and pressure decomposition of the starting oil number one, to form gas and carbon, increased with increase of temperature and pressure. At 1 atmosphere the percentage decomposed ranged between 10 and 47.5 per cent as the temperature increased from 550 deg. to 700 deg. C. At 11 atmospheres the per-

centage of oil decomposed to form carbon and gas increased from 32.7 to 68.0 per cent under the same temperature conditions.

Oil number two at 3 temperatures and atmospheric pressure decomposed more readily to gas and carbon than oil number one. With increase of pressure the stability of oil number two was much greater, with the exception of one run at 700 deg. C., where a slight increase was noted in gas and carbon formation.

Conclusions

1. Two naphthene base oils were subjected to temperatures of 550 deg., 600 deg., 650 deg., and 700 deg. C. and to two pressures of 1 and 11 atmospheres. The decomposition products of the oils to be studied were gasoline, unsaturateds, benzene, toluene, and xylene formation.

2. The two naphthene base oils, although somewhat similar in characteristics as to distillation and specific gravity analysis, gave widely different percentage yields of gasoline, unsaturateds, benzene, toluene, and xylene under the same conditions of temperature and pressure. This emphasized the importance of the starting oils in cracking phenomena when yields of certain types of hydrocarbons are desired in maximum quantity.

3. Increase of temperature and pressure increased the decomposition of the starting oils. At the same temperatures an increase to 11 atmospheres gave a lower percentage yield of recovered oil. The specific gravity of the recovered oils increased with increase of temperature and pressure.

4. For every 100 gal. of oil used the maximum percentages of aromatic formation at atmospheric pressure and 650 deg. C. gave a total for benzene, toluene and xylene of 14.1 per cent. The individual aromatic hydrocarbon percentage upon the basis of 100 gal. of oil used gave for benzene 2.6 per cent, for toluene 4.7 per cent, and for xylene 6.8 per cent. At 11 atmospheres the total percentage formation at 650 deg. C. was 18.2, and for the individual aromatic hydrocarbons, for benzene 7.2 per cent, for toluene 5.9 per cent, and for xylene 5.1 per cent.

5. At atmospheric pressure the maximum percentage yield of gasoline upon basis of 100 gal. used was 19.3 per cent at 650 deg. C. With increase of pressure to 11 atmospheres, and a temperature of 600 deg. C., the yield increased to 26.2 per cent. Increase of pressure is favorable for gasoline or low-boiling-point hydrocarbon formation.

6. The percentages of olefins or unsaturateds in the gasoline cut to 150 deg. C. ranged between 8.6 per cent and 42.3 per cent. Increase of pressure decreases the formation of olefins in the gasoline cut.

7. The percentage of starting oil decomposed to form carbon and gas increases with increase of temperature and pressure. The minimum of 10 per cent of carbon and gas was formed at 550 deg. C. and 1 atmosphere pressure, and the maximum of 69.3 per cent at 700 deg. C and 11 atmospheres.

EXPERIMENTAL DATA

The experimental data are given in the form of tables.

Table 1—The per cent of recovered oil and the specific gravity of the recovered oil at temperatures 550 deg., 600 deg., and 700 deg. C. at 1 and 11 atmospheres pressure.

Table 2—The distillation cuts of the recovered oils.

Table 3—The comparison of the specific gravity of the distillation cuts of the recovered oil.

¹Brooks, Jour. Franklin Inst., 180, 653, 1915.

Table 4—The percentage of olefins in the distillation cuts.

Table 5—The percentages of benzene, toluene and xylene in the recovered oil.

Table 6—The percentages of benzene, toluene and xylene on basis of oil used.

Table 7—The percentages of gasoline in the recovered oils.

Table 8—The percentages of gasoline on basis of oil used and the specific gravity of the gasoline.

Table 9—The percentage of olefins in the gasoline cut.

Table 10—The effect of temperature and pressure. The percentages of olefins on basis of oil used for production.

Table 11—The percentages of the starting oil, decomposed to form carbon and gas.

Department of Inorganic Chemistry,
Columbia University, New York City.

The (British) Institute of Metals

The annual autumn meeting of the Institute of Metals was to be held on Wednesday, Sept. 20, commencing at 4 p. m., in the rooms of the Chemical Society, Burlington House, Piccadilly, London. Sir George T. Beilby, F.R.S., LL.D., was to preside, and the following papers were to be presented:

The Allotropy of Silver. By W. D. Helderman.

Cadmium in Spelter. By W. R. Ingalls.

The Annealing of Arsenical Brass Containing 61 and 62.5 per cent of Copper. A Study of the Structure and Properties Developed by Varying the Rate of Cooling Within the Transformation Range. By C. H. Mathewson and E. M. Thalheimer.

The Development of the Spelter Industry. By Ernest A. Smith.

CORROSION RESEARCH STATION

The Government Research Council having made a grant of £1000 per annum toward the cost of carrying on the research inaugurated by the Institute of Metals Corrosion Committee into the causes of the corrosion of marine condenser tubes, it has been found possible by the Corrosion Research Committee, which has recently been re-constituted so as to include representatives of all bodies interested in the subject, greatly to extend their sphere of activities.

Two salaried investigators have been appointed in the persons of Capt. G. D. Bengough, D.Sc., and Dr. O. F. Hudson. They will conduct scientific researches on the committee's condenser plant now about to be installed by the courtesy of the Brighton corporation, in the Brighton Electricity Works. The plant will be worked under ordinary industrial conditions, the microscopical and other examination of the metal treated at Brighton being carried out in the metallurgical laboratories of the Imperial College of Science & Technology, South Kensington.

Electrolytic Zinc.—The Electrolytic Zinc Co., Inc., of 3 South William Street, New York, which has been successfully operating an electrolytic zinc plant at Baltimore, Md., for several months is now turning out about eight tons per day of high grade spelter running 99.92 + zinc. The raw materials used are scrap zinc and prime western spelter.

The new warehouse of the Schoellkopf Aniline & Chemical Works, Inc., Buffalo, N. Y., is expected to be ready for occupancy by Nov. 1. The plans for the building, which consists of four stories and basement, with floor area of over 150,000 sq. ft., were started just four and one-half months ago.

History of the Flotation Process of Inspiration*

By Rudolf Gahl, Ph. D.

Metallurgist in Charge of Concentrator, Inspiration Consolidated Copper Co.

The history of flotation in America is very short, at least as far as the large-scale application of the process is concerned. It is remarkable how many important developments have taken place in the last few years and are already being extensively utilized. What was new a year ago seems almost commonplace now. For this reason it is with hesitation that I follow the suggestion of Dr. Ricketts, president of the Institute, to describe the experiences of the Inspiration Consolidated Copper Company with the flotation process.

Tests Conducted in Small Test Mill

When the Inspiration company first decided to build a concentrating plant, nothing was known about flotation, and the process was to be gravity concentration pure and simple.

DEMONSTRATION TESTS CONDUCTED BY MINERALS SEPARATION COMPANY

While plans were being prepared by H. Kenyon Burch (who had been intrusted with the design and construction of the concentrator) the Minerals Separation Company, a concern at that time little known in America, asked and obtained permission to demonstrate the value of its flotation process for Inspiration ore. As a consequence, a small 50-ton flotation machine of standard design was added to the company's test plant and started to operate in the beginning of 1913. This marks the beginning of flotation at Inspiration.

The results obtained with this machine, which was operated by members of the Minerals Separation staff, so far surpassed what this company anticipated that it was decided to continue flotation tests for this purpose, two of the flotation experts of the Minerals Separation Company, I. L. Greninger and G. A. Chapman, were retained. L. R. Wallace, now superintendent of the Miami works of the International Smelting Company, was at that time metallurgist of the Inspiration company and in that capacity took an active part in these tests. Great credit is due to him for his quick recognition of the possibilities of flotation.

FLOTATION TESTS CONDUCTED BY INSPIRATION COMPANY

The tests led to the conclusion that it would be advisable to incorporate flotation into the concentrating process. Doubt existed only as to the extent to which this should be done. The first design brought out by Mr. Burch only called for flotation treatment of the concentrator tailings. While the tests were progressing, it became more and more evident, however, that flotation should form a more essential part of the milling process, and it was finally decided to leave out all the complications which are usually adopted in gravity concentration plants for the purpose of recovering as much as possible of the mineral values of the fines, and to rely on flotation alone for this purpose.

SAMPLING OF OREBODY

This decision was reached only after it had been established by numerous tests that the orebody as a whole was suited for flotation treatment. It was found, it is true, that a portion of the ore in the mine was unsuitable for flotation by the process in question, but the amount of this ore was established to be only a

*A paper presented at the Arizona meeting of the American Institute of Mining Engineers, September, 1916.

small fraction of the total. Besides, the tests proved that the ore contained in this fraction lost its refractory character when mixed with the rest of the ore.

Mr. Greninger gives the following description of the manner in which these tests were carried out:

"Sample lots, each amounting to about 10 tons and representing from 30 to 35 ft., were blasted from the back and sides of the drifts and after suitable crushing and grinding treated in the small flotation machine mentioned above.

"The results were very erratic, some showing good recovery with a high grade of concentrate, while others returned concentrate of a very low grade and also showed a low extraction.

"After a considerable number of tests had been made it was found that the good results were always obtained when treating ore of a schist gangue, while poor results resulted when the gangue was the altered and kaolinized granite which forms a part of the Joe Bush orebody.

"Ten-ton samples were taken from various parts of the mine for the purpose of determining the extent and amount of this granite ore. These lots were taken from the drifts crossing the orebody from south to north, starting in the granite ore and continuing along each drift until the schist gangue was encountered.

"In all of these tests the results were uniformly good while treating the schist ore and poor while treating the granite ore.

"Subsequently, another series was inaugurated with the view of determining the amount of granite ore that could be mixed with the schist ore without interfering with the treatment of this mixed ore by flotation.

"Various percentages of granite ore were mixed with clean schist and the mixture treated by flotation. It was found that 10 per cent of granite caused no change in the behavior of the ore in the flotation plant, and when 20 per cent of the granite was mixed with the schist ore only a slight difference was noted, this difference consisting in a slight lowering of the grade of the concentrate with a corresponding falling off in extraction."

The conditions described by Mr. Greninger are well illustrated by a drawing made by C. E. Arnold of the

mine engineering staff of the company, which represents laboratory flotation results on samples taken from a drift in the Joe Bush orebody (Fig. 1). The results show clearly that the granite by itself does not interfere with flotation, but only the fault material, evidently corresponding to what Mr. Greninger terms kaolinized granite.

OTHER RESULTS OBTAINED IN SMALL TEST MILL

The test conducted in the small test plant established in a general way the physical conditions under which Inspiration ores could be treated advantageously; for instance, it was decided that raising the temperature did not improve the results obtained in proportion to the extra expense of such procedure.

As far as flotation oils are concerned, those in charge of the tests came to the conclusion that cresylic acid (98 per cent pure) should be used as the main flotation agent, and should be supplemented by crude turpentine. As the most important result brought out by these tests, I consider the discovery that the flotation agents may profitably be added in the grinding machines, while it had formerly been the customary practice to add the "oils" in agitating tanks especially provided for the purpose. This discovery had an important bearing on the later developments in the Inspiration milling practice, inasmuch as it paved the way for the use of much heavier oils; for instance, coal tar, which it is impossible to amalgamate thoroughly with the pulp in agitating tanks. Mr. Chapman, I think, made this important discovery during this period (U. S. Patent 1,102,874).

The details of the flow sheet to be followed were left to be decided by tests on a larger scale. Only this much was settled: That no concentration of any kind, either flotation or gravity, should be attempted before the ore was reduced to the fineness required for the flotation process. This decision was brought about by the fact that excellent recoveries were obtained when this procedure was followed, and was, of course, also strongly urged by considerations of simplicity in the milling process and cheapness of milling operations.

In these tests a 50-ton flotation machine of Minerals

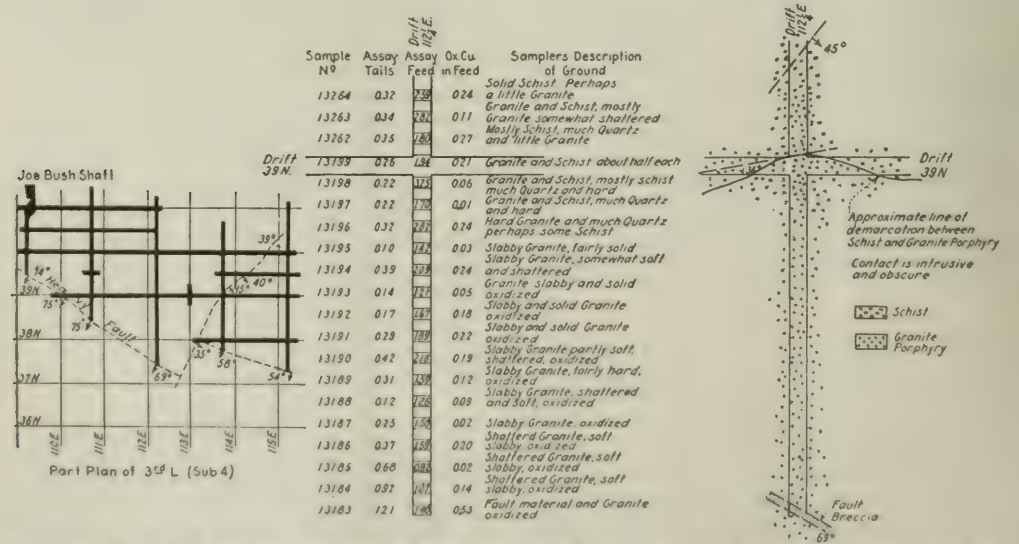


FIG. 1—MAP SHOWING GEOLOGY AND RESULTS FROM LABORATORY FLOTATION TESTS ON 5-FT. SAMPLES TAKEN AT 10-FT. INTERVALS ALONG DRIFT BETWEEN 37.40 AND 39.35 N.

Separation Company Standard type was used. In the general design, it was similar to the larger machine later put in use. It had eight agitating compartments with propellers of 12-in. diameter revolving with a peripheral speed of from 1200 to 1400 ft. per minute.

Tests in Large Test Mill

FLOW SHEET

In order to test on a large scale the points already settled in the small test mill, and to decide the points left undecided by the small-scale experiments, a 600-ton test plant was built and put into operation at the beginning of January, 1914. It was my privilege to conduct those tests in co-operation with Mr. Greninger, who represented the Minerals Separation Company, and with the representatives of other concerns, who in the course of time decided to submit flotation machines to the consideration of the Inspiration company. The flow sheet of this 600-ton test mill was extremely simple. It is illustrated in Fig. 2.

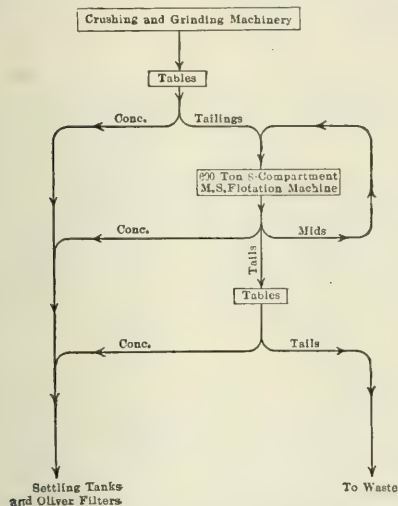


FIG. 2—FIRST FLOW SHEET OF 600-TON TEST MILL, INSPIRATION CONSOLIDATED

The ore after being crushed to the desired fineness by machinery, which was tested out at the same time, was sent to tables; from these the concentrates went to the concentrate bins, while the tailings passed on to an eight-compartment flotation machine of the Standard Minerals Separation type with 24-in. stirrers. Later a twelve-compartment machine of the same type was added and operated in parallel with the eight-compartment machine. The tailings from the flotation machines were passed on to other tables, the concentrates from which, combined with the concentrates from the upper tables and the flotation machine, went to the concentrate bins, while the tailings went to waste. The flotation machine was operated in the standard manner, the feed being introduced into the first agitating compartment, passed to the first spitzkasten, drawn to the second agitating compartment, sent from there to the second spitzkasten and drawn to the third agitating compartment, etc., the agitators forming the necessary suction for the transportation of the pulp from the spitzkastens to the following agitating compartments. A final concentrate was made from one or more spitzkastens, while the concentrate from those remaining was

considered a middlings product and was returned to the head of the machine for retreatment.

This flow sheet was extremely simple, but after awhile even this was considered too complicated, inasmuch as the necessity of table treatment ahead of flotation treatment was doubted.

DISCUSSION OF THE VALUE OF PRELIMINARY TABLE TREATMENT

The advantages pointed out in favor of the preliminary table treatment were about as follows: Since the tables would make a certain recovery, an impoverished flotation feed would result and assist the flotation machine to make a tailings product low in copper. However, the validity of this argument was doubted for the following reasons:

In the first place, if complications are to be avoided, the preliminary table treatment has to be of a comparatively rough character; the refinements of hydraulic classification have to be dispensed with, as by its use more water would be introduced into the pulp than would be advisable for the following flotation process. It must be taken into consideration that the pulp delivered to the tables already contains about 3 tons of water to 1 ton of solid matter, experience having shown that the grinding machines, consisting of either ball or pebble mills, deliver a product of the desired fineness, about 1 or 2 per cent on 48-mesh, when the consistency of the overflow from drag-belt classifiers, working in conjunction with the grinding mills was carried at about this figure; experience also showed that this consistency is suitable for the flotation treatment, while greater dilution of the pulp resulted in an increased copper loss. The logical way out of this difficulty would be to introduce settling tanks, for which, however, the modern mill designer has a just abhorrence; at least, when they are to be placed in the middle of the mill. Neither the liberal use of dressing water nor a low tonnage rate would be permissible for the same reason. On this account, a high recovery could not be expected from a preliminary table treatment. During our tests it averaged around 33 per cent.

Furthermore, the assumed fact, that an impoverished feed results in a better recovery of the flotation machine was strongly doubted by some of the flotation experts, who claimed that in order to form a froth which had the necessary carrying power for mineral it would be better to leave as much mineral as possible in the feed to the flotation machine. In other words, their advice was to leave out the tables in order to permit the flotation machines to do more efficient work.

There is no doubt, however, that tables will catch a certain amount of mineral (especially coarser grains) which will escape in the flotation process. For this reason, tables have to be used to insure the highest recovery,¹ but it seems that tables following the flotation treatment would make up for this deficiency of the flotation machine better than tables ahead, inasmuch as they would not work under the disadvantage, known to every millman, of receiving too rich a feed. It is well known that it is possible to make a much lower table tailing working on feed containing a small percentage of copper than on a feed rich in copper. From theoretical speculations, therefore, no valid reason was advanced that increased recovery should result from table treatment ahead of the flotation treatment.

The next argument advanced by the supporters of a preliminary table treatment was, that it would result in an improvement of the grade of the general concentrates, inasmuch as it would be possible to make a

¹This applies only to the flow sheet under discussion.

very clean product on the tables, thereby raising the general average of the concentrates. There is evidently some sound foundation for this point; how much, could not well be investigated without resorting to actual experiments.

A third point seemingly in favor of preliminary table treatment is this: Flotation concentrates offer more or less difficulty in mechanical handling; vacuum or pressure filters have to be resorted to for this purpose. It was pointed out, therefore, that if a certain percentage of the total concentrate could be saved on the tables, and a table concentrate produced containing only a small amount of the slime, so troublesome in filter treatment, it might be a decided advantage; the quantity of concentrate to be handled on filters might be materially reduced and economies effected in this manner. At the same time, experience shows that the flotation concentrate resulting under those conditions, because it contains less of the coarser sand, is more difficult for the filters to handle than it would be were the sand left in. Very likely, therefore, no decided improvement in the handling of the concentrates would

In January and February, 1914, the lower table floor was not in operation. For this reason, the flotation tailings were not treated on tables. There was, however, table treatment ahead of flotation, the following results being obtained: Table recovery, 39.42 per cent; flotation recovery, 33.35 per cent; total recovery, 72.77 per cent. From March to August, 1914, various flow sheets were tried; tables were sometimes used pre-

TABLE I—COMPARISON OF EFFICIENCY OF FLOW SHEET No. 1 (FIG. 2) AND FLOW SHEET No. 2 (FIG. 3)

Description	FLOW SHEET	
	No. 2	No. 1
Assay of mill feed	1.72	1.67
Assay of flotation machine feed	1.72	1.32
Assay of flotation machine tails	0.46	0.43
Assay of lower table tails	0.29	0.30
Assay of general concentrates	32.71	31.72
Recovery upper tables + flotation machine	74.30	75.30
Recovery flotation machine	9.40	7.40
Additional recovery on lower tables	83.70	82.70
Total recovery	25.70	23.20
Tonnage per deck on lower tables	87.00	87.00
Tonnage per deck on upper tables	0.95	0.82
Oil consumption, cresol + turpentine in pounds per ton		

REMARKS.—The recoveries are calculated from the feed and tailings assays and the assay of general concentrates.

CONCLUSIONS.—Roughing on upper tables reduces the tailings assay of the flotation machine slightly, while it does not seem to affect the assay of the lower tables appreciably. Increased recovery results from the use of the lower tables.

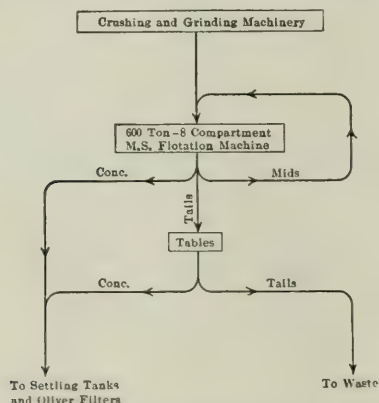


FIG. 3—SECOND FLOW SHEET OF 600-TON TEST MILL, INSPIRATION CONSOLIDATED

result from the separation of the table concentrates from the flotation concentrates, at least under the conditions prevailing here.

The same objections do not hold true for tables when used after the flotation process, as in that case no limitations are imposed regarding the hydraulic and dressing water, and the tables cannot help but make an additional small recovery of concentrate. On account of the fact that the table feed is necessarily low in copper, the tailings will be correspondingly low. In all cases, therefore, where flotation treatment does not make a full recovery, or practically so, of mineral values, tabling after flotation seems imperative.

Although such theoretical considerations were indulged in, no decision was based on them. To settle the main points in question, a series of tests was carried out. On alternate days, the "upper" tables were bypassed (Fig. 3) while on the remaining days, they were utilized.

Table 1 gives the résumé, on the strength of which it was decided to use secondary tables only and to leave the preliminary table treatment (ahead of the flotation treatment) out of the flow sheet to be adopted in the concentrator under construction. That this conclusion is justified seems to be borne out by the foregoing facts.

This remark again refers only to the flow sheet under discussion

ceding and sometimes following flotation, and sometimes in both places. The figures on recovery are, for this reason, not comparable with the preceding ones. From September to December, 1914, no tables were used preceding flotation; the flotation tailings were, however, treated on tables. The results obtained were: Flotation recovery, 70.83 per cent; table recovery, 7.51 per cent; total recovery, 78.34 per cent.

CALLOW FLOTATION INSTALLATION

While the test mill was in operation, Mr. Callow, president of the General Engineering Company, advised the Inspiration company that he had invented and perfected a new flotation process which, in his opinion, would give as good, if not better, results than the machine of the Minerals Separation Company. As a consequence, arrangements were made to add a unit of machines of the Callow type. The flow sheet using Callow cells is illustrated in Figs. 4 and 7. It consisted of four rougher flotation cells, which served for

the production of a low-grade concentrate, and another cell of the same construction which was supplied for the purpose of cleaning the concentrates made on the rougher cells. The tailings resulting from the cleaner cells were returned and mixed with the pulp entering the rougher cells. With the machine was furnished a Pachuca tank for the purpose of mixing flotation oil into the pulp entering the plant, should it be more desirable to do this in addition to or in place of feeding the oil to the grinding machines, as had proven useful both in the

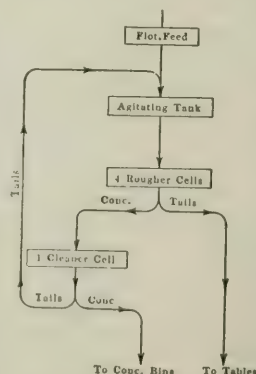


FIG. 4—FLOW SHEET OF EXPERIMENTAL CALLOW FLOTATION PLANT

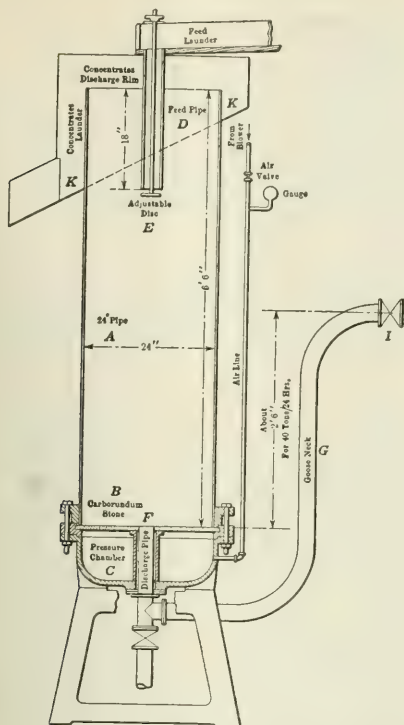


FIG. 5—FLINN-TOWNE FLOTATION MACHINE

small and in the larger test plants. As a matter of fact, the use of the Pachuca tank was abandoned after several months' operation.

The Callow cells work on a different mechanical principle from that underlying the Minerals Separation Standard machine, inasmuch as no movable parts are used for the purpose of producing the fine dissemination of air with the pulp, which seems to be essential for any kind of flotation machine; while the Standard Minerals Separation machine depends on the operation of fast-revolving impellers, the dissemination is effected in the Callow machine by blowing air through the pores of a porous blanket, which forms the bottom of each cell.

The Callow machine, illustrated in another paper is ingeniously simple. The feed enters at the upper end of the inclined bottom, while the tailings are discharged through the float valve at the lower end, the concentrates overflowing at the top of the flotation tanks. The porous bottom of the cell is set on an incline to make possible the treatment of feed containing coarse sand. The movement of such sand particles from the feed to the discharge end is thereby accelerated.

The mechanical principle of aeration and agitation by the admission of air through a porous medium, which has been termed "pneumatic flotation," was undoubtedly discovered by Mr. Callow³ and his associates independently of other inventors, although an earlier patent had been taken out for the same thing in Eng-

land by Minerals Separation (British Patent, 10,929, May 3, 1910) and long before the installation of the Callow machine at this mill, Inspiration ore had been tested in New York by a pneumatic flotation machine constructed jointly by Messrs. Flinn and Towne.⁴ The results of this test were so good that a small test plant of this system was installed at Inspiration.

FLINN-TOWNE INSTALLATION

The Flinn-Towne machine, as mentioned, utilizes the pneumatic principle also but the application is somewhat different. An illustration of a single Flinn-Towne machine is given in Fig. 5, while Fig. 6 shows the outline of the installation. The cells are constructed in the shape of cylindrical tanks, the bottoms of which are formed by the porous medium. The feed enters near the top in the center of the cylinder, while the tailings leave the machine through a center hole in the porous medium. In the Flinn-Towne installation, only one roughing machine was provided, while additional cells served for the purpose of cleaning both rougher tailings and rougher concentrates. The tailings produced by the concentrate cleaner cell were returned to the head of the roughing cell. In place of the canvas blanket of the Callow machine, Messrs. Flinn and Towne in the demonstration test at Inspiration used carborundum stones as the porous medium through which the air is injected into the pulp.

COLE-BERGMAN INSTALLATION

The Flinn-Towne machine was withdrawn from the contest after a competitive test between this machine and others had run for several months, although the results obtained looked very encouraging. Its place

³Mr. Callow refers to his installation at the National Mill, Mullan, Idaho, April, 1914, as the first successful commercial plant utilizing the pneumatic principle.

⁴This test was made in the presence of Dr. L. D. Ricketts, consulting engineer, and W. D. Thornton, vice-president of the Inspiration company. According to F. B. Flinn, a 600-ton plant of the Flinn-Towne flotation system was shipped to the Tezuitlan Copper Co. in Mexico in the Spring of 1913. This could not be put into operation on account of the political conditions prevailing then. Otherwise, this would have been the first commercial pneumatic flotation plant.

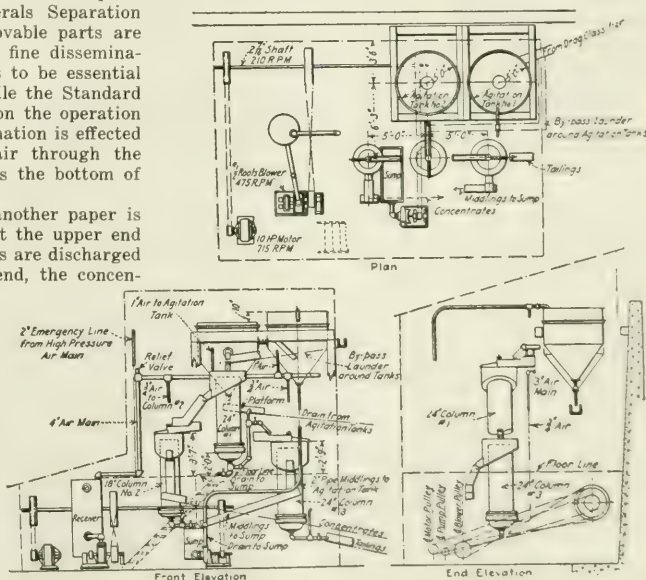


FIG. 6—OUTLINE OF FLINN-TOWNE FLOTATION INSTALLATION

was taken by a flotation machine designed by Messrs. Cole and Bergman.

Their machine is illustrated in Fig. 7. In principle the cells are similar to those of the Flinn-Towne machine. Evidently, the designers tried to improve on this system by mechanically developing the idea underlying the machine, and by changing one point, which in their opinion formed a weak part of the Flinn-Towne machine. This is the construction of the porous diaphragm, which, as explained below, was formed by a round carborundum disk.

While carrying on the test of the Flinn-Towne machine, it proved necessary occasionally to wash the carborundum stones by injecting a water pipe from the top and even by removing the stones and cleaning them with water, acids, etc. Messrs. Cole and Bergman ascribed this deficiency to the fact that on account of

for the purpose of cleaning the concentrates produced on the larger machine.

METHODS FOLLOWED IN COMPETITIVE TESTS

In the interest of a fair contest between the flotation machines of the different types, each machine was provided, as nearly as possible, with the same character of pulp as the rest. In the beginning this was accomplished by providing each machine with one or more pebble mills to which feed was sent in such quantities that a mill product of practically the same fineness resulted in each case.

When the results of the competitive tests began to approach each other very closely, the equalization of the pulp furnished to the different machines was still improved upon by mixing the ground product discharged from all the mills, and sending it to a divider

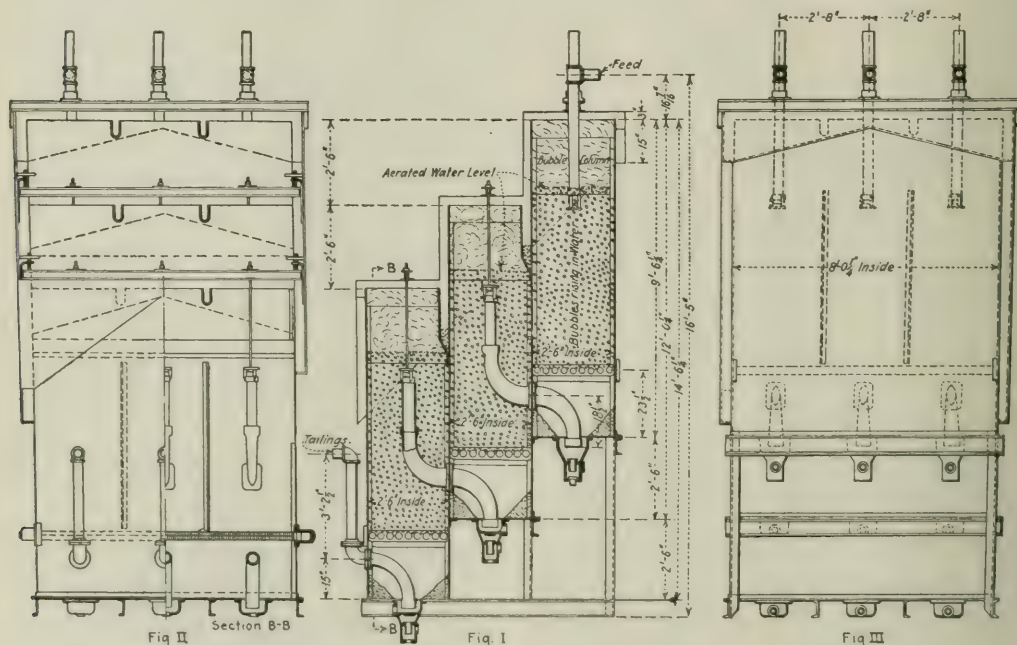


FIG. 7—COLE-BERGMAN FROTHING CLASSIFIER

the horizontal position of the porous medium, sand had a tendency to lodge thereon and to impede or prevent the passage of air through the pores. They substituted, therefore, a system of perforated tubes covered with a suitable fabric, such as canvas or flannel.

This led to the construction of a porous medium in the form of a grate, as shown in the illustrations. Their idea seems to be a very happy one, as it makes it possible to apply the flotation process to ore pulps containing comparatively coarse particles of sand; for instance, it seems possible to treat with this machine ore mixtures that contain sand particles as coarse as ten-mesh and perhaps even coarser. Using this machine, the millman is now in a position to treat slime by flotation without the necessity of removing it from admixture with sand.

The Cole-Bergman machine has given good results in our tests as have the rest of the machines utilizing the pneumatic principle. It was operated in conjunction with a smaller machine of the same type installed

which permitted the division into as many parts as there were competing machines, and in any proportion desired.

As it had been decided in former experiments not to install tables ahead of the flotation process, no preliminary table treatment was used during the competitive tests, but each flotation system was furnished with a set of tables for the retreatment of the flotation tailings.

It developed that this was essential in trying to arrive at a fair valuation of the machines, as some of the machines produced tailings from which additional mineral could be extracted by the table treatment more easily than from the tailings of other flotation machines, the cause evidently being that flotation machines of one type have a tendency to save more of the finer particles, while flotation machines of another type permit of a better recovery of coarser grains.

Those flotation machines that make a good recovery on the sand, but leave a larger percentage of mineral

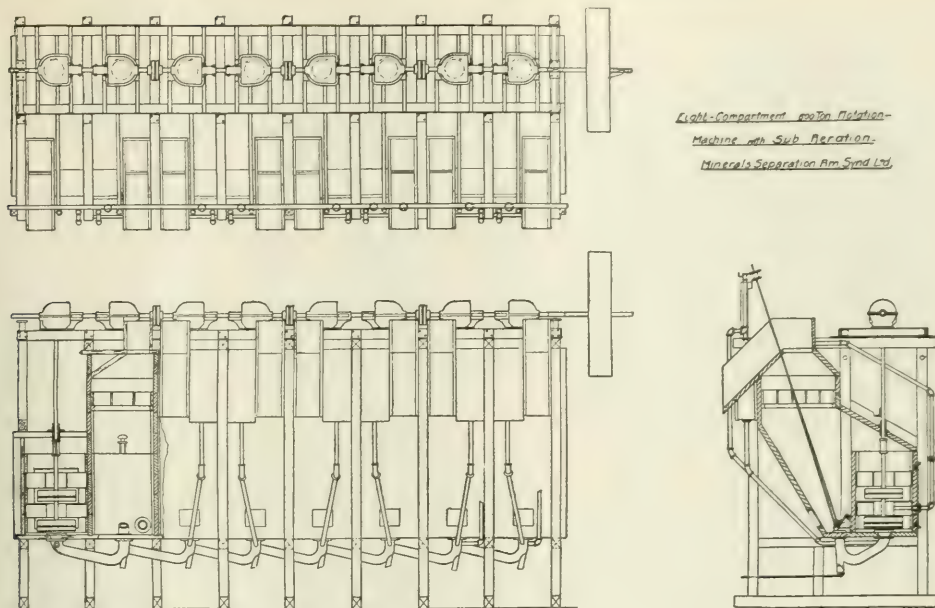


FIG. 8—MINERALS SEPARATION SUB-AERATION TYPE OF FLOTATION MACHINE

in the slime, will not benefit from a subsequent table treatment as much as those of the other kind.

ADVANTAGE OF PNEUMATIC FLOTATION MACHINES

In the course of the tests at Inspiration, the fact became apparent that, by the application of the pneumatic principle, a higher recovery of the slime is made possible than without the utilization of injected air, although the Standard Minerals Separation machine also gives excellent results when the tonnage is reduced to a considerably lower figure than the machine is supposed to be able to treat economically.

Therefore, in cases where high power consumption is of little importance, the Standard Minerals Separation machine will fill the requirements of a flotation machine remarkably well. When, however, the power consumed has to be seriously considered, it seems advantageous in the light of the Inspiration experiments to make use of pneumatic flotation for the reason pointed out above, i.e., that poor work of flotation machines on sands can be made up by a subsequent table treatment, while poor work on slime cannot. Within certain limits, it is more important to insist on machines effecting a good slime recovery than on machines making a good sand recovery.

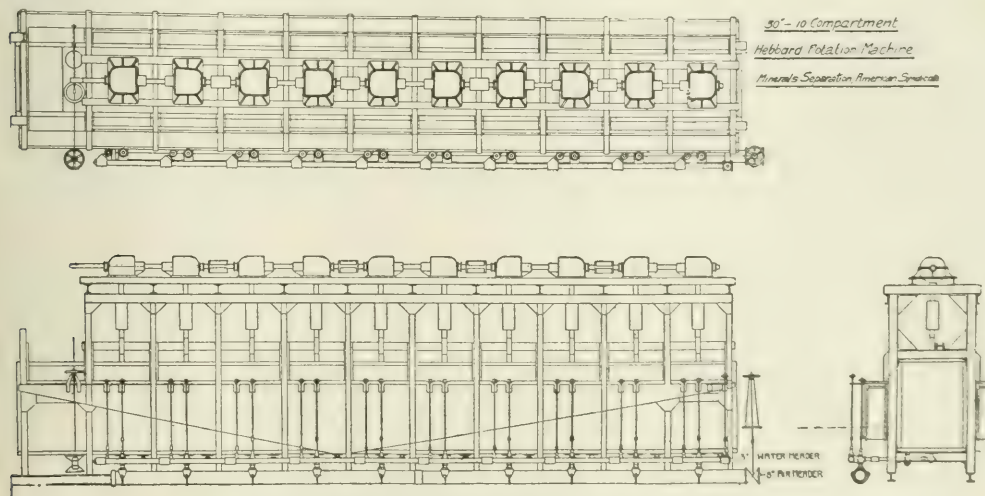


FIG. 9—HEBBARD TYPE OF MINERALS SEPARATION MACHINE

PNEUMATIC MACHINES OF MINERALS SEPARATION COMPANY

The Minerals Separation Company, realizing this, offered to put in their subaeration type of machine which added the advantages resulting from the use of injected air to the advantages which their Standard machines seemed to have in saving coarser mineral. This resulted in the construction and testing successively of two of their subaeration type machines, one in which the old spitzkastens still were retained, and another one in which they were dispensed with. As seen from the illustration (Fig. 8) provisions were made in the former machine to admit air to the pulp conduits carrying the pulp from the spitzkastens to the agitating compartments next in succession, in order to make this air available to lift mineral to the top of the spitzkastens where it can be skimmed off. The agitating compartments are closed at the top by covers set

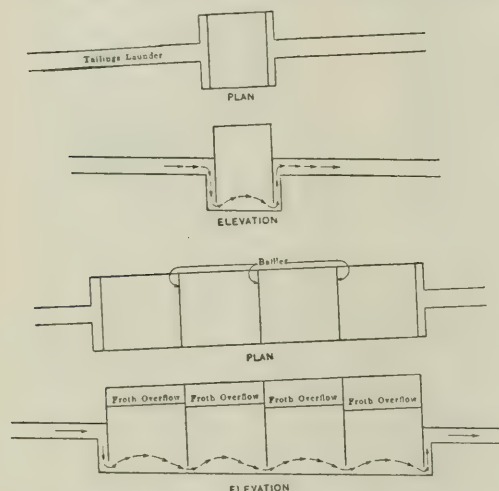


FIG. 10—DIAGRAM SHOWING ORIGIN AND DEVELOPMENT OF INSPIRATION FLOTATION MACHINE

on an incline in such a way that the air rises to the top in the agitating compartments and is conducted to the spitzkasten, being thereby utilized for the purpose of carrying the mineral values.

This construction of the Minerals Separation Company was, however, only an intermediate step toward the design of the second-named machine, a machine of greater simplicity, which is similar in principle to the one illustrated in Fig. 9. The machine consists of a long rectangular tank without any partitions, in which a number of agitators revolve, while air is injected underneath each impeller. We call the machine the "Hebbard Type" Minerals Separation Machine.

In order to limit the agitation to the lower part of the machine and to provide an area of comparative quietness in the upper part, a system of baffles is arranged above the agitators. As a consequence, the froth is given a chance to separate out in the upper portion of the rectangular tank, and flows off on both sides lengthwise into launders provided for the purpose.

This machine marks an important progress in the development of the Minerals Separation flotation systems toward increased recovery of copper, at least as far as the Inspiration ores are concerned. In our tests it effected a higher recovery of the fine mineral particles than the old machine had accomplished. The

machine also has the advantage of greater simplicity and relatively low power consumption. The only drawback that we have found in the operation of the machine, extending over a number of months, is that the agitating shafts, which are suspended from above, have a tendency to bend and, if not straightened, soon cause the impeller blades to strike against the baffles, breaking one or the other.¹

FLOAT SKIMMING DEVICE

While the competitive tests of the different flotation machines were being conducted, it was observed that large quantities of mineral froth frequently appeared in the tailings launders. The idea suggested itself to remove the froth, thus increasing the recovery obtained in the flotation machines and concentrating tables by an additional small amount. After some experimenting, a way was found in which this could be easily accomplished. The tailings launder was widened and deepened for some distance. The tailings stream was forced to pass underneath a baffle on entering the widened space, and was also forced to travel under another baffle board at the end of the space, thus being made to rise through the restricted area formed by the tailings end baffle and the back-wall of the float-saving device, which is illustrated in Fig. 10.

Contrary to what might be expected, tailings sand of the fineness of Inspiration tailings will not lodge in the widened-out space unless the length is greater than a certain critical distance, nor will it choke the upward channel in the tailings end of the machine. When conditions demanded the construction of the float-saving device in greater length, it was found that the accumulation of sand, which has a tendency to form in the middle of the machine, can be avoided by arranging an additional baffle not reaching quite to the bottom in the center of the machine. If the machine is built longer yet, more than one intermediate baffle is necessary. The explanation for this behavior of the pulp, which at first glance might seem paradoxical, is that, on account of reduced passageway between the lower part of the baffles and the bottom of the machine, the pulp is forced to travel through at speed so high that it will not permit the settling out of sand. As a consequence, a hydrostatic head will establish itself between front and back of such a baffle and has to be taken care of in the design. It is found, however, in actual practice, that the hydrostatic head required to keep the sand from settling out by creating an accelerated current underneath the baffle is relatively small.

A similar consideration explains the fact that the upward tailings passage at the end of the machine has very little, if any, tendency to choke; to take care, however, of possible choke-ups that might be caused by the discharge of coarse rocks, pieces of wood, etc., into the pulp, it was found advisable to arrange some air jets in the bottom of the upward tailings passage to assist in clearing it whenever necessary.

INSPIRATION FLOTATION MACHINE

This device was in actual operation for several months at our test mill and made itself pay well by adding 1 per cent to the recovery actually obtained.

The question then presented itself as to whether this device, which was successful in saving mineral escaping from the flotation machines, could not be transformed into a flotation machine itself by arranging for the injection of finely distributed air into the pulp passing through the machine. The development of the idea led to what we call our Experimental Inspiration

¹This trouble is alleviated in the Hebbard machines turned out more recently by the Minerals Separation Co. by the provision of suitable bearings for the impeller shafts in the bottoms of the machines.

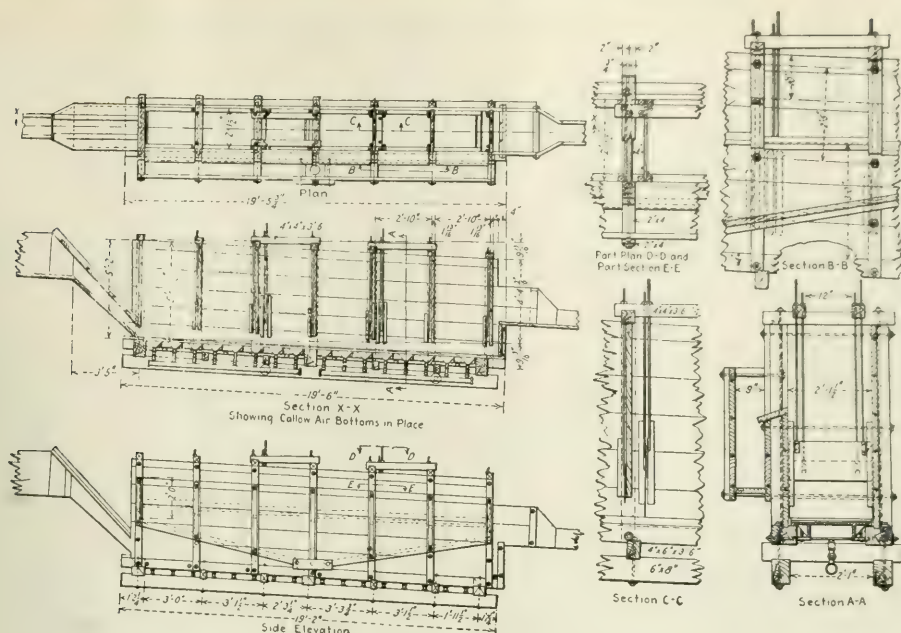


FIG. 11—EXPERIMENTAL INSPIRATION FLOTATION MACHINE

Flotation Machine, which was built on a small scale, that is of a size to treat up to 100 tons in 24 hr., and was placed in competition with the other flotation machines already in existence. This machine is illustrated in Fig. 11.

The air was injected through a porous bottom arranged in a way similar to the bottoms of the Callow and Flinn-Towne machines (as a matter of fact, a Callow bottom was used in the first tests) and the concentrate flowed over the edge on one side of the flotation tank.

The mode of operation followed was also similar to the one developed for the other air machines. A low-

grade concentrate was produced and retreated on a similar machine of the same construction, called the cleaner machine, the tailings from which were returned to the head of the roughing flotation machine.

As will be seen from the drawing, the construction of this machine is extremely simple and comes pretty near to an ideal of Mr. Mills, our general manager, who prophesied that the flotation machine of the future would be nothing but a launder with provisions for injection of air. The method of effecting the concentration in two stages was also followed when the new types of the Minerals Separation machines were put into commission.

ARRANGEMENT OF CALLOW CELLS IN SERIES

In principle, the Inspiration machine shows one difference from the Callow machine; viz., that instead of splitting the pulp between a great number of machines, it is forced to travel through a series of compartments in succession. This is the same policy that had also been followed in the construction of the Minerals Separation machines. The question then came up, whether it might not be of advantage to arrange the Callow cells also in series. To test out the idea, the flow sheet of the Callow plant was changed (see Fig. 12). The primary feed was sent to two of the cells, the other cells receiving the tailings from these primary cells.

This arrangement showed at least no disadvantage over the multiple treatment; it seemed superior to the other system in the one respect that it showed at a glance whether the cells were operated well, because in that case most of the concentrate would be produced on the primary cells while the secondary cells would produce a rather light-colored froth and would add only a small fraction to the recovery made on the primary cells. Both primary and secondary concentrates were treated jointly in a cleaner cell, while the tailings from

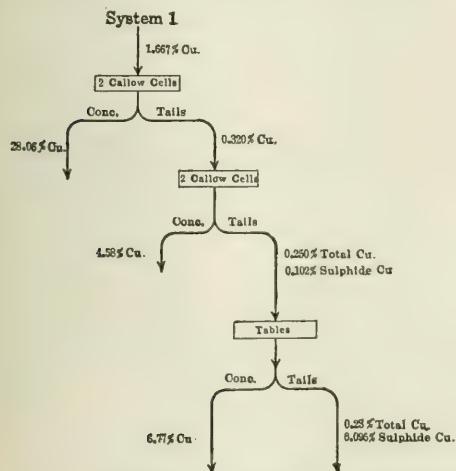


FIG. 12—TESTS WITH CALLOW CELLS IN SERIES

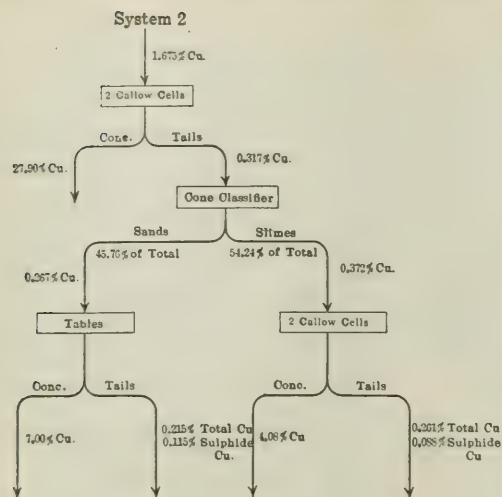


FIG. 13—TESTS WITH CALLOW CELLS IN SERIES, WITH CLASSIFIERS BETWEEN

the secondary cells were conveyed to a number of concentrating tables for retreatment.

A variation of the latter flow sheet was also tested (compare Fig. 13). Between the primary and secondary cells, a cone classifier was interposed for the purpose of making a separation between the sand and slime. The slime was sent to the secondary flotation machines, while the sand was passed to tables. This latter flow sheet was finally decided upon for the Calow installation in the large concentrator. Tests made with the object of establishing which of the two is superior, resulted in a tie. Some of the figures on this point are given in Table II.

is wise to send the cleaner tailings back to the head of the rougher machine for retreatment. In the limited time at our disposal, it proved impossible to substitute something better, but the chances are that the same holds true of flotation that is true for water concentration; viz., that middlings are sent back for retreatment mainly because the designer does not know anything better to do with them. In principle it seems wrong to follow this practice, because when heavy copper losses occur in concentrating machines which express themselves in high tailings, there is always a doubt as to whether this is due to poor recovery made in the primary treatment or to heavy losses incurred by middlings sent back for retreatment.

COAL TAR AS FLOTATION AGENT

It was to be expected when the flotation process was installed in our test plant, that there would be ups and downs in the recovery because the process was rather new, especially in its application to chalcocite ores. For the month of June, 1914, the recovery obtained in the test mill showed a sudden drop, and the serious problem confronted us of establishing the cause and finding a remedy. Some of the flotation experts suggested that it might be due to the fact that a new shipment of cresylic acid which had been received and used, at that time might not fill the specifications of being 98 per cent pure. We did not feel competent to say whether the impurities actually amounted to more than 2 per cent. We were, however, inclined to think that perhaps cresylic acid, which is, as is well known, one of the products resulting from fractional distillation of coal tar, might not represent the fraction most suitable for the flotation of our ores. Having no coal tar available in the neighborhood, we proceeded to make some by distilling a sample of ordinary New Mexico soft coal and separating the tar thus formed into the fractions distilling off at different temperatures.

Our facilities for testing oils were limited at that time. The Minerals Separation Company's represent-

TABLE II—RE-TREATMENT OF TAILINGS FROM TWO CALLOW CELLS. SCREEN ANALYSIS OF FEED AND TAILS OF SECONDARY CALLOW CELLS

Mesh	SYSTEM 1								SYSTEM 2							
	FEED				TAILS				FEED				TAILS			
	Per Cent Weight		Per Cent Cu		Per Cent Weight		Per Cent Cu		Per Cent Weight		Per Cent Cu		Per Cent Weight		Per Cent Cu	
	Cum.	Indiv.	Cum.	Indiv.	Cum.	Indiv.	Cum.	Indiv.	Cum.	Indiv.	Cum.	Indiv.	Cum.	Indiv.	Cum.	Indiv.
65	5.0	5.0	0.29	0.014	5.0	5.0	0.21	0.011	0.05	0.021	0.06	3.8	3.8	0.20	0.007	4.0
100	19.0	14.0	0.25	0.035	19.2	14.2	0.15	0.021	0.06	10.6	6.8	0.25	0.017	10.8	6.8	0.14
150	32.2	13.2	0.29	0.039	32.4	13.2	0.16	0.021	0.10	10.6	8.0	0.25	0.017	10.8	6.8	0.14
200	42.4	10.2	0.33	0.034	42.8	10.4	0.21	0.022	0.11	18.6	8.0	0.30	0.024	19.0	8.2	0.25
	100.0	57.6	0.35	0.201	100.0	57.2	0.27	0.155	0.20	100.0	81.4	0.40	0.326	100.0	81.0	0.30
Average			0.32	0.323			0.23	0.230	0.15			0.374			0.28	0.280
Standard Dev.			0.32				0.23		0.15			0.370			0.26	

Comparison of results obtained from two different methods as shown in Figs. 12 and 13.

NOTE: The concentrates from the flotation cells were in both cases returned to the head-size Calow cells; the retreatment tailings being returned to the head of the primary cells.

Tonnage rate in system 1.....49.3
Tonnage rate in system 2.....47.5
CONCLUSION: See advantage is apparent in favor of either system. System to be installed should be decided from mechanical points.

VARIATIONS OF FLOW SHEET

In the way of other flow sheet variations, etc., only one thing was tried to any extent; that is, whether it

ative did not believe in small-scale tests, and for this reason did not recommend experiments with small testing machines. Nevertheless, it seemed desirable to have something with which to carry out small-scale laboratory experiments. Dr. Ricketts, who was aware of our troubles and realized the importance of such tests, was kind enough to send us a little electrically operated emulsifying machine, which served admirably for qualitative tests. We also built a testing machine based on the principle of the Standard Minerals Sepa-

ration machine, with the difference, however, that instead of sending the pulp from one agitating compartment to a spitzkasten and then into another agitating compartment and spitzkasten, we made the pulp return from the first spitzkasten to the original agitator, forcing it to revolve in a closed circuit. Our laboratory machine is illustrated in Fig. 14. Lately a machine based on the same principle has been put on the market and is sold by the Denver Fire-Clay Company. Thus, we had a chance to try the different fractions of our home-made coal tar.

The chemist who conducted these tests (Mueller) hit on the idea that it might be well, in addition to trying the different fractions, also to test the coal tar as a whole. The results were very surprising, since they showed that by the addition of crude coal tar we could effect a greater recovery than we were able to obtain by the use of highly refined cresylic acid. From this point dates our experience that it is better to use coal tar than soluble flotation agents like cresylic acid to save coarse mineral. Cresylic acid is an extraordinarily good agent for producing froth, but the froth which it produces does not seem to have as much carrying power for coarse mineral as that produced by coal tar. Not all coal tars are equally good for this purpose. Tests in laboratory machines easily show the difference between coal tars of different origin.

The system that we used to carry out such tests has been described, although without authorization, by William A. Mueller, one of my former assistants who took part in these laboratory tests.⁴

It is difficult to utilize coal tar in plants using flotation supplementary to gravity concentration, on account of the fact that it is not easy to effect a good amalgamation of tar with the pulp in agitating tanks, and even in mechanical flotation machines. The use

of coal tar lends itself very well indeed to the system of feeding tar into the grinding machines, a system that, as mentioned above, had been worked out in our small test mill and patented by Mr. Chapman.

The company is indebted to Mr. Callow for proving the merits of coal-tar creosote as a flotation agent by using it in his demonstration plant at Inspiration. After we had established the value of coal tar by laboratory tests, and while efforts were being made to obtain it commercially, he applied creosote successfully. We have continued to use it for a long time, mostly in combination with coal tar, and have only recently dropped it, as we find crude coal tar cheaper and better.

EXPERIENCE WITH PRIMARY SLIME

After the first difficulty that we encountered in our large-scale tests had been solved by the introduction of coal tar into the flotation-oil mixture so far used, things went along fairly well for some time until a new difficulty was encountered.

It happened that once in a while an abundant froth was produced on the flotation machines, but this froth seemed to have very little carrying power for the mineral contents of the ore and held mainly finely divided gangue. It was observed that this phenomenon occurred with special severity whenever the ores shipped to the test mill contained a large amount of fines and a small amount of coarse rock. It was attributed, therefore to the presence of what may be called primary slime, that is, slime not formed by the crushing of ore in the mill, but originating from the mine.

That the falling down of the flotation machines was caused by variation of the ores was proven by the fact that samples of the refractory ores when treated in the laboratory testing machine, gave as unsatisfactory results as the corresponding ore did in the big flotation machines.

To demonstrate that the presence of the original

slime caused the trouble, samples of the mill feed were separated into sand and by screening them on a 200-mesh screen. The oversize, when reduced to the proper fineness for flotation treatment, did not offer the least trouble and yielded a high-grade concentrate in the laboratory machines, while the undersize proved extremely refractory (refer to Table 31).

The same experiment was repeated on a large scale, the products from a Marcy ball mill crushing to about six-mesh being treated on

⁴William A. Mueller: Use of Coal Tar in Flotation, *Engineering and Mining Journal*, vol. 100, No. 15, p. 591 (Oct. 9, 1915).

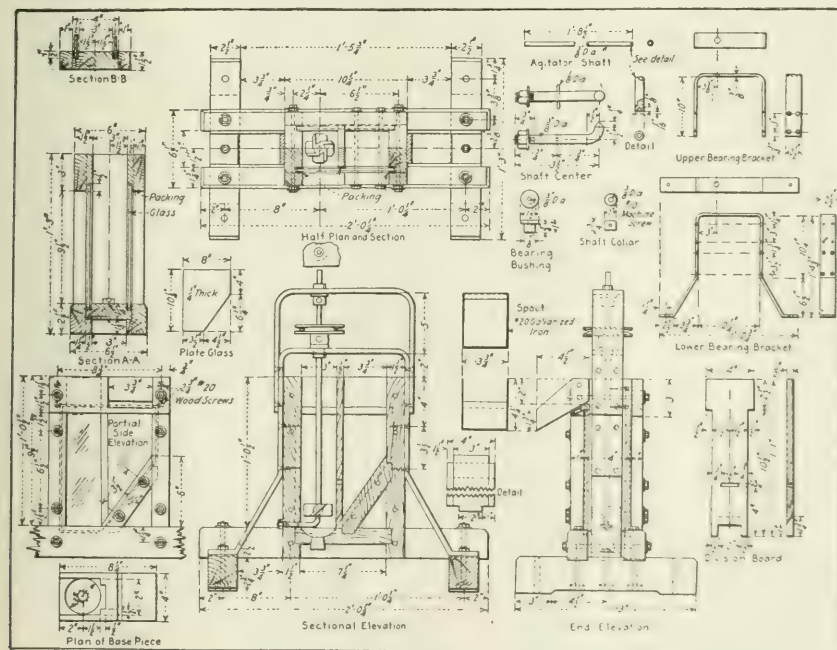


FIG. 14—LABORATORY FLOTATION MACHINE

We have not yet reached a point where we can safely give the reason for the action of the iron introduced into the flotation pulp. It is sure, from the experiments referred to, that the same results, as by grinding with balls, could be obtained by introducing the iron in finely divided form, say in the form of filings, into a pebble-mill pulp. We supposed for a while, and I am not yet certain that this supposition is incorrect, that the metallic iron might react on the impurities contained in solution in the mill water and introduced therein with the primary slime. We find, as a matter of fact, that our ores contain very little in the nature of soluble salts, and that whatever they do contain is mainly confined to the primary slime. For this reason, in laboratory tests we have tried repeatedly to substitute pure water for the water contained in the mill pulp. In every case we have noted some improvements in the results obtained. We have also found that when we separate the water from refractory pulp, treat it with iron filings, and add it to the original pulp again, we get a certain improvement in the recovery, but we

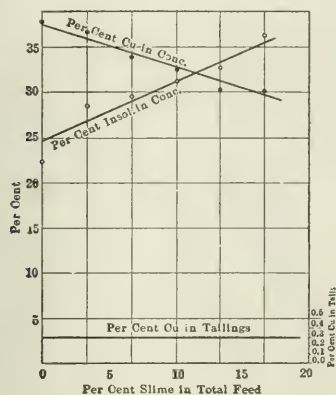


FIG. 16—INFLUENCE ON FLOTATION OF MIXING PRIMARY SLIME AND REGROUND SAND

have not been able to get an improvement equally as good as that obtained by direct introduction of finely divided iron into the pulp.

For this reason, we have often thought that the effect of iron is physical rather than chemical in char-

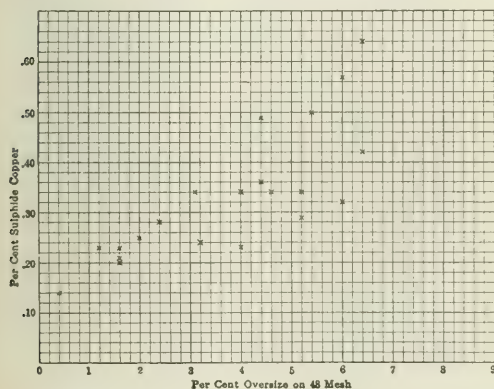


FIG. 17—RELATION BETWEEN COARSENESS OF FLOTATION MACHINE FEED AND COPPER SULPHIDE ASSAY OF CALLOW FLOTATION TAILING

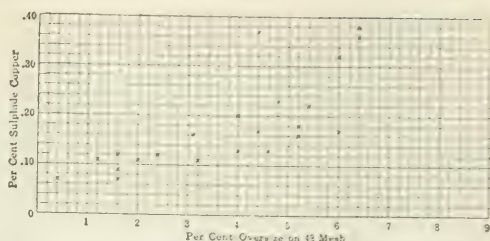


FIG. 18—RELATION BETWEEN COARSENESS OF FLOTATION MACHINE FEED AND COPPER SULPHIDE ASSAY OF CALLOW TABLE TAILING

acter. The iron exists in the pulp, at least partly, in the metallic form, as can be proven by the use of the magnet. If necessary the effect of the iron could be increased by removing the iron contained in the tailings pulp by means of electromagnets and returning it to the mills or the flotation machines. Although we have considered the possibility of applying this fact commercially, we have not yet done so.

I have been told by several people that they have tested the influence of finely divided iron on their ores and have not obtained any improvement whatever. This shows, evidently, that metallic iron is not a universal remedy for all flotation troubles, but as far as our primary slime is concerned, our experience leaves no doubt about its usefulness, and I believe the figures quoted above are positive enough to bear out my statement. As a curiosity I have included in Table IV some figures showing the influence of the addition of zinc filings to ore that without the addition does not offer any difficulty in the flotation treatment.

INFLUENCE OF CHEMICALS ON PRIMARY SLIME

We also found that the harmful influence of primary slime can be counteracted by the introduction of certain chemicals; for instance, we have used advantageously sodium hydroxide or potassium cyanide. The use of sodium hydroxide was recommended to us by the Minerals Separation Company, which, I understand, applied it first in the plant of the Caucasus Copper Company.

FINENESS OF CRUSHING DESIRED

Tests to determine the most advantageous fineness for treatment of the ore according to our flow sheet, that is, flotation machines followed by tables, naturally formed an essential part of our tests. Results of this character are plotted in Figs. 17 and 18 and seem to indicate that to get the best results grinding should be carried to such a point that not more than about 1 or 2 per cent of the pulp will remain on a 48-mesh screen (Tyler type). The grinding at our large concentrator is at present carried closely to this point.

(To be concluded)

Powdered Metals in France.—The consumption of powdered metals in France before the war had an annual value of 12,000,000 francs, according to the *Bulletin de la Societe D'Encouragement*. These powdered metals were imported from Germany (none being made in France), and were used in a great variety of products. Since importations have been cut off the manufacture of these powdered metals has been taken up in France by the firm of Caplain-Saint-Andre et Fils at Rantigny (Oise), after conducting preliminary experiments. This company manufactures considerable metal foil and as this is the first step in the powdering process it was natural to take up powdered metals.

Note on the Occurrence and Significance of Twinned Crystals in Electrolytic Copper*

By Henry S. Rawdon

Until recently but scant attention has been paid to the structure and properties of metals prepared electrolytically. This is largely due to the fact that this method of preparation is used primarily as a refining process, and that the metal is to be melted or at least severely worked before being put into the form it will have in service. Copper electrotype plates form an exception to this, the physical properties of such sheets, as deposited, determine to a large degree the wearing qualities of the finished electrotypes. The results of

the observations referred to below are from the examination made of several series of such electrotype plates, experimentally prepared for the purpose of studying the conditions of deposition which affect their properties.

In the microscopic examinations made the frequent occurrence of twinned crystals was noted. Crystals of this type are common in many metals and alloys, their occurrence being considered as valuable evidence of the history and treatment of the material previous to the time of observation. Until recently such crystals have been regarded as the result of strain and structural distortion followed by annealing. Edwards¹ has, however, recently shown that in the case of tin, zinc, and cadmium at least, such forms can result directly upon the application of mechanical stress without following this by annealing the sample.

In general, the microscopic structure of the copper "shells" observed is in accord with the observations of Sieverts and Wippelmann² and Faust³ upon similar material. Without entering into detail as to effect of temperature, concentration of solution, etc., the microstructures of deposits obtained in the ordinary acid sulphate bath may be summarized as follows: (1) with low current density the crystals are large and well formed, except at the surface of initial deposit, where a thin layer similar to (2) below is seen (Fig. 1-A); (2) with higher current density the crystals become long and finger-like, giving a columnar appearance to the sections as seen under the microscope (Fig. 1-B); (3) with higher current density the structure is considerably broken up and twinned crystals are common (Fig. 1-C). Fig. 2 gives a case showing an excessive amount of twinning.

Copper, in common with most metals, crystallizes in the cubic or regular system. This fact together with the orientation of the various crystals may be demonstrated by deeply etching the polished surfaces used for microscopic examination. The attack is not uniform from crystal to crystal, nor within any individual crystal. The surface of the crystals shows a pitted appearance due to this unequal attack, each pit being in the form of some portion of a cube, the actual shape depending upon the relation of the polished plane to the interior arrangement of each crystal. The pits on any one crystal face are all of the same shape and arrangement.

The crystalline structure corresponding to the "twinned" condition is illustrated in Fig. 2-b by this etching method. Crystals *a* and *a'* are twinned with respect to the remainder of the crystal *A*. The crystalline units, as indicated by the three-sided pyramidal pits (the cut-off corners of the cubes) are all of the same orientation in crystal *A*; in crystals *a* and *a'* they are oriented alike, but are related to those of crystal *A* as an object is to its mirror image. In crystals *a* and *a'* the structural units, whatever they may be, have been rotated through an angle of 180 deg. so as to assume the position they do with respect to the original arrangement which still persists throughout the remainder of the crystal. Such a rearrangement within a crystal does not happen spontaneously, but requires the application of force to bring it about.

The crystals are twinned to right angles to the direction of "growth," all the twinned layers being parallel within any one crystal. This fact suggests very strongly that they are formed during the process of deposition.

Fig. 1 shows the variations in microstructure of electrolytic copper:

Fig. 1 (a) refers to a current density of 0.41 amp. per square foot, temperature of solution 38 deg. C. The

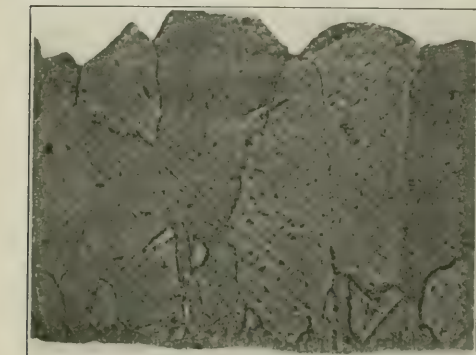


FIG. 1A

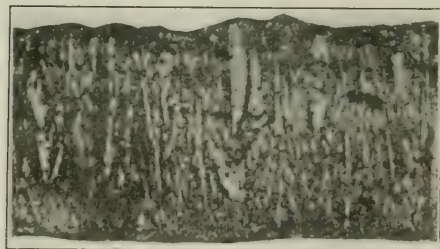


FIG. 1B

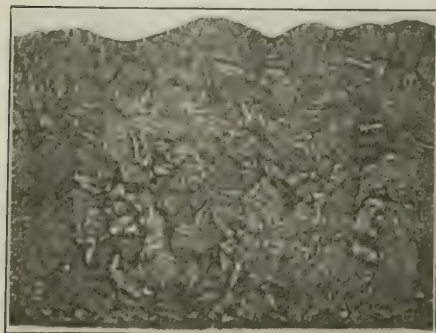


FIG. 1C

FIG. 1 (A), (B), (C)—VARIATION IN MICROSTRUCTURE OF ELECTROLYTIC COPPER

¹Edwards, *Trans. Inst. Metals*, XIV, p. 116; 1915.

²Zell. anorg. Chemie, 1915, 91, 100, 1-14.

³Zell. anorg. Chemie, 1912, 78, p. 201. Faust also points out the occurrence of twinned crystals in such material.

initial layer adjacent to the cathode face is finely crystalline.

Fig. 1 (b) refers to a current density of 0.57 amp. per square foot, temperature of solution 25 deg. C. This is the common form of deposit, often isolated crystals larger than the average show evidence of twinning.

Fig. 1 (c) refers to a current density of 0.73 amp. per square foot, temperature of solution 25 deg. C. The "twinned" crystals (parallel markings) are numerous in this type of deposit.

Magnification, 300x; etching, 1-1 ammonia hydroxide, followed by immersion in hydrogen peroxide. The lower side, in each case, is the initial deposit, i.e., adjacent to the cathode.

Fig. 2 shows twinned crystals in electrolytic copper:

Fig. 2 (a) refers to a current density of 0.925 amp. per square foot, temperature of solution 28 deg. C. The deposit is unusual in the amount of twinning shown. The metal was deposited from left to right. The twinned layers (alternately light and dark) are perpendicular to the direction of "growth."

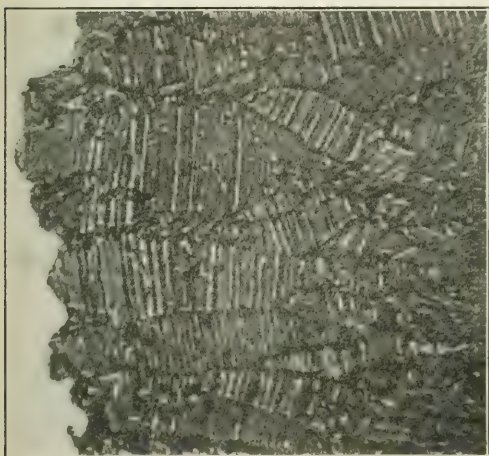


FIG. 2A

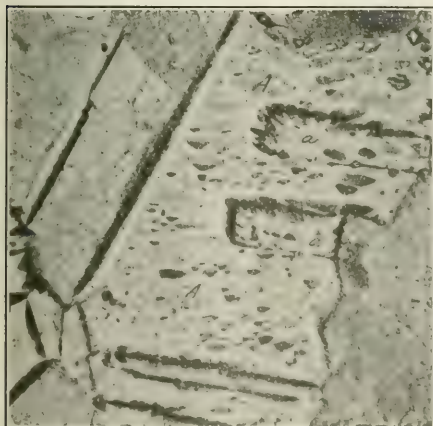


FIG. 2B

FIGS. 2 (A) AND (B)—TWINNED CRYSTALS IN ELECTROLYTIC COPPER

Fig. 2 (b) similar to "a" after annealing at 600 deg. C. (approximately). The metal has recrystallized. Magnification, 500x; etching as for Fig. 1.

The simplest explanation of the origin of these twinned forms is that the rotation of the crystalline units comes as a consequence of the side pressure of neighboring crystals during the process of "growth." The condition illustrated by Fig. 1-b is a common one for the conditions used; in such deposits it is often noted that a crystal, which for some reason has grown much faster than its neighbors, is almost invariably found in the twinned condition. The initial layer of the deposit on the cathode face consists of fine columnar crystals closely crowded in together and all "growing" at much the same rate. On account of the small crystal size no twins can be detected in this layer. As the deposit increases in thickness some crystals "grow" at the expense of the adjacent ones which are thus suppressed and "die" out. This is partially due to the tendency of the crystals to grow sidewise as well as outward, as is shown in the increasing width of the fortunate ones as their length increases. The mutual side thrust exerted by the growing crystals is enough in many cases to cause the layer which is being deposited upon any one crystal to assume the position of twinning with respect to the immediately preceding layer.

The occurrence of the twinned crystals in itself, so far as is known, does not materially affect the mechanical properties of a metal. The fact that they are brought about by the application of energy, however, is a very suggestive index of the mechanical properties. It is only when the mutual side pressures upon the crystals exceed a certain value that twinning occurs; in all other cases the metal remains in a state of constant stress, amounting in the effect upon the properties to a virtual "cold working" of the metal. It is a well-established fact that metals which are under stress as a result of "cold working" or other cause have decidedly different properties than when such stresses are relieved.

The hardness of a metal is one of the properties which is notably affected by the mechanical working of the material. Metals highly stressed are much harder than when these stresses are relieved. The hardness measurements of Sieverts and Wipplemann¹ are in accord with the observations and inferences here made. They found the inner layer directly adjacent to the cathode face to be of nearly uniform hardness in all the deposits measured while the outer side was decidedly softer. A series of measurements made at the Bureau of Standards of the ultimate strength and elongation of specimens cut from the copper deposits is in general accord with the observations of the microstructure. The results obtained for specimens showing the fine columnar type of crystals are uniformly much higher than for the other extreme (approximately two times as much). This is partially due to the difference in crystals; size cut should not be attributed entirely to this.

It has been shown² that upon annealing bronze only in case the metal has been distorted or strained is there any recrystallization occurring. This recrystallization is nearly always accompanied by the twinning of some crystals. The same is true for copper and copper-rich alloys in general. In case the deposits of electrolytic copper are in a stressed condition as has been suggested, upon annealing the metal should assume the characteristic polyhedral forms with the accompanying twinned forms. Several samples showing characteristic types of microstructure were annealed for very nearly

¹Loc. cit. The hardness was measured by the scratch method using the Martens instrument.
Bureau of Standards Technologic Paper No. 60.

two hours at a temperature of approximately 610 deg. C.

The large crystalline deposits, *i.e.*, those made with low current densities, after annealing show no appreciable change in the crystal size or arrangement (Fig. 3-a). The initial thin columnar layer of such plates, however, has recrystallized and shows frequent twinned crystals. This is in accord with hypothesis; this fine columnar layer adjacent to the cathode face was assumed to be in a state of stress because of its resemblance to those deposits which show the characteristic twinned forms and because of the relatively high uniform hardness of this side. Its behavior upon annealing as recorded in the changed microstructure bears out the correctness of this assumption. The outer large crystals which show no evidence of having been interfered with during their growth, and are consequently in a state of little or no stress, should not be expected to show any recrystallization upon annealing.

Fig. 3 shows the effect of annealing upon microstructure.

Fig. 3 (a) refers to material of Fig. 1-a, after annealing two hours at approximately 600 deg. C. The finely crystalline layer of initial deposit (lower side) has recrystallized and shows twinning; the remainder has remained unchanged. Magnification, 350x.

Fig. 3 (b) refers to material of Fig. 1-c after a similar heating. The entire layer has recrystallized

and shows numerous twins and marked change of crystal size. This appearance is typical for all deposits except those similar to Fig. 1-a. Cold-worked copper after annealing shows a similar microstructure. Magnification, 300x.

Etching as for Fig. 1.

On the contrary, all the other plates annealed, recrystallized into the characteristic polyhedral forms, many of which are twinned. The microstructure has been completely changed, as was to be expected. The parallel columnar type of deposit, even though no twinned forms, or at least few, were found before annealing, has changed as completely as the deposits in which such twins are common.

In order to make certain that the twinned forms observed before long annealing are not due to any slight heating during the mounting and preparation of the specimen for microscopic examination, some samples were mounted between two lead plates and without any heating whatever were polished and examined. The same structure was observed. None of the samples had received any rough treatment, so that the formation of these twinned forms cannot be attributed to mechanical disturbance of any kind. The existence of the metal in a highly stressed condition previous to heating is clearly pointed out by the following decided changes in the microstructure brought about by the annealing: (1) The "recrystallization" of the metal or change to the common polyhedral type; (2) the increase of size of the new form of crystals, and (3) the numerous twinned lamellæ existing in the new structural forms.

SUMMARY

It is to be concluded that the physical properties of electrolytic metals, particularly in the form of thin shells or plates, cannot be ascribed to differences of crystal size alone. The properties of most such deposits are very similar to those of metals "hardened by cold working." It must be concluded, then, from the behavior upon annealing that such deposits, except those at low current densities, are in a condition approximating such a "cold-worked" state, and that the properties are those to be expected from such a condition. Though the study was made for a particular industry, the application of this conclusion in other fields, *e.g.*, electroplating, is obvious.

Bureau of Standards,
Washington, D. C.

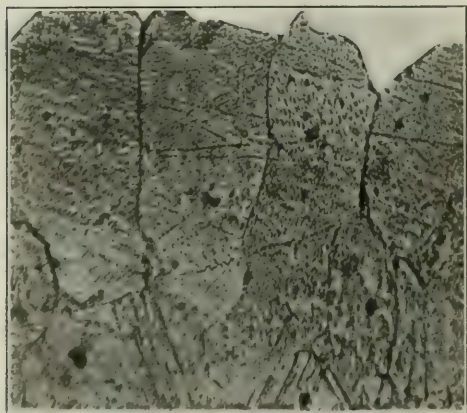


FIG. 3A

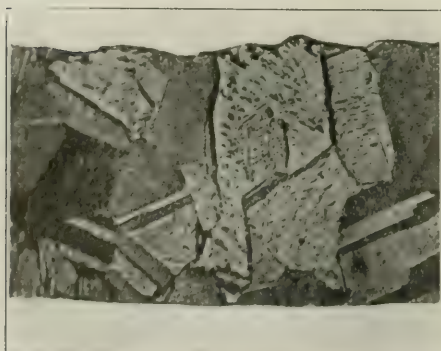


FIG. 3B

FIG. 3 (A) AND (B)—EFFECT OF ANNEALING ON MICROSTRUCTURE

The tenth annual meeting of the American Peat Society was held at Washington, D. C., Sept. 21 to 23. The headquarters were at the Hotel Raleigh. Fifteen different papers were presented on the uses of peat and the peat industry by prominent specialists.

Properties of Plastic Fire Clays.—The Bureau of Standards has recently completed an investigation of some European plastic fire clays and published the results as Technologic Paper No. 79. The properties of five well-known European plastic fire clays used in the manufacture of glass refractories, graphite crucibles, etc., have been studied. The content of shrinkage and pore water, the drying shrinkage, fineness of grain, mechanical strength in the dried state, the Atterberg plasticity number, rate of vitrification, and softening temperature have been determined. A comparison is made of these materials as to their suitability for several purposes, and tentative specifications are suggested for the selection of clays which might be used as substitutes for these foreign materials. American clays are available which, if used as mixtures, can take the place of the imported ones with equally as good or superior results.

NOTES FROM THE PALMER PHYSICAL LABORATORY.

Examination of the Electrical Properties of "Fibrox"

By E. F. Northrup

At the April, 1915, meeting of the Electrochemical Society at Atlantic City, N. J., Dr. E. Weintraub described and showed samples of the remarkable fibrous inorganic material which he calls *fibrox*. Dr. Weintraub generously furnished the writer a sample lot of the material and thus made possible the tests which are described below.

For the benefit of those not acquainted with Dr. Weintraub's paper (Trans. of the Electrochem. Soc. Vol. XXVII, 1915, pp. 267-276) the nature and properties of fibrox are here briefly summarized: Fibrox is formed by the slow chemical union of CO with the vapor of silicon, giving a product of the possible composition SiCO. When prepared in the manner described by Dr. Weintraub, in which it is essential that there shall be a slow interpenetration of the reacting gas and vapor, the resulting fibrox is characterized by the following physical properties:

It is a soft, resilient, fibrous material of a pale greenish-blue color. It can be cut into sheets, or other forms which are self-supporting. If a mass of fibrox is wet with water it collapses into a formless slime.

It is an agglomeration of exceedingly fine fibers which can only be seen by direct vision with the aid of a lens. They are said to be between 0.3 and 0.6 micron in diameter.

The apparent density of the mass is more or less variable with different samples and is given by Dr. Weintraub as 2.5 to 3 grams per liter—though some samples studied by me ran somewhat higher than this.

The volume of air occupied by the mass of the material figures out as about 99.5 to 99.9 per cent. As a consequence of this large air-content the specific heat of a mass of fibrox is exceedingly small and the curious result follows that a mass of fibrox can be held for an indefinite time in a hot flame and then be immediately grasped by the hand when withdrawn from the flame; a slight sense of warmth only being felt. In other words fibrox is a material which cannot be made to stay hot for even brief intervals.

The heat-resistivity of fibrox is most exceptional, and as a heat-insulator, which will at the same time withstand a very high temperature, (in a reducing atmosphere to at least the melting point of Bessemer steel, and probably higher), it has no superior. It runs about 2300 thermal ohms per cm² at 200 deg. C. It is non-hydroscopic.

The most surprising property of fibrox is that, instead of being as one would suppose, a most perfect electrical insulator, it conducts electricity exceedingly well. It is this property that the writer first decided to examine, to above 1100 deg. C.

As will be seen by the results which are given in curves, the variability of the electrical resistivity with measurements made at different times and under different conditions is such that no definite figures of resistivity can be assigned to fibrox in the mass. The curves are of interest, however, in showing the general character of the electrical conduction of this material in the mass and how it is modified by elevation in temperature. No attempt was made to determine how the resistivity might be modified by a change in the current-density of the measuring current. The effect of increasing the current through the sample is given in Dr. Weintraub's paper where it is shown that an increase in current decreases the resistance. My measurements

were all made with about 0.02 amp. (60-cycle current) through the specimen, which presented a section normal to the direction of the current of 15 cm².

The method employed in making the measurements was in all respects identical with the method employed by the writer in his determination of the "High-Temperature Resistivity of Refractories," described by him in METALLURGICAL AND CHEMICAL ENGINEERING, February, 1914.

The samples of fibrox supplied the writer were in several pieces which were not equally dense and coherent. Three slabs of fibrox (to represent average quality) were cut out with a high speed circular saw (which worked very well—better than a razor). The dimensions of each slab were chosen 0.7 cm. thick by 5 cm. long by 3 cm. wide. These three slabs were clamped between graphite slabs in the manner shown in Fig. 1 in the article above referred to. The graphite slabs were drawn together with the graphite screws until the slabs of fibrox were compressed from a thickness of 0.7 cm. to a thickness of 0.2 cm.

Using these dimensions and measuring the resistance between the two terminals of molybdenum attached to the two inner graphite slabs the resistivity per cm.² of the sample is given by multiplying the measured resistance by the factor 112.5. The resistance was measured, using A. C., with a Wheatstone bridge and Rowland electro-dynamometer and the temperatures were measured with a Pt vs. Pt + 10 per cent Rh thermocouple. The sample was heated in the writer's graphite furnace. (See METALLURGICAL AND CHEMICAL ENGINEERING, Jan. 1914), and was exposed to a reducing atmosphere of CO + N.

The procedure was to take simultaneously frequent readings of resistance and temperature as the furnace was slowly heated (the temperature being carried in the first test to 1108 deg. C.) and then to continue taking readings as the furnace was permitted to slowly cool.

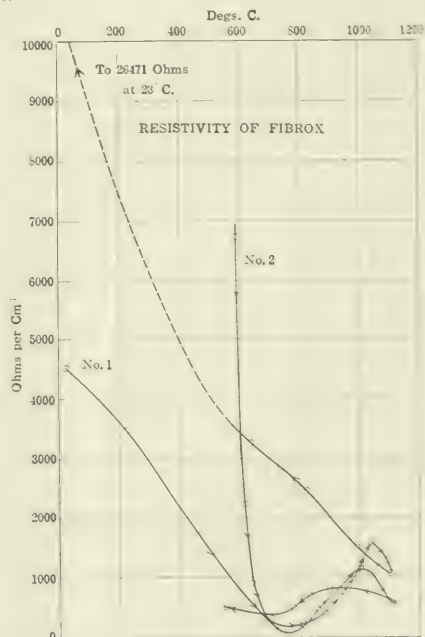


FIG. 1—RESULTS OF FIRST TEST

The results obtained in this first test are shown in curve No. 1.

There is no question but what the curve represents the true and gradual lowering of the resistivity from the beginning of the measurements at a temperature of 40 deg. C. to the highest temperature obtained, 1108 deg. C.

It is very doubtful, however, if any reliance is to be placed upon the course of the curve after the furnace started to cool. The reason for this conclusion is based on the observation made of the sample after the test was completed when it was found that the slabs of fibrox had completely lost all their resilience and were so loosely clamped between the graphite slabs that large contact resistances might easily be present.

The curious inflections in the curve at 760 deg. and 1000 deg. C. are, the writer assumes, real phenomena. To test this assumption the same specimen was measured a second time up to a temperature of 1117 deg. C. Before the second set of measurements was begun the slabs of graphite were drawn together with screws until the slabs of fibrox were again clamped tightly. This reduced the thickness of the latter to 0.1 cm. and made the multiplier 225 to change resistance into resistivity.

It was found that the resistivity at room temperature (26.7 deg. C.) had permanently risen to 33,750 ohms. The resistance, however, fell with great rapidity as the temperature was raised and followed a curious curve No. 2 (Fig. 1) and plotted to a smaller scale, No. 3 (Fig. 2). This curve (No. 2) shows inflections of exactly the same kind, at about 750 deg. and 1040 deg., as did the first curve, which is very strong evidence against their accidental or erroneous character.

It is indeed unfortunate that fibrox is an electrical conductor, for were it a good insulator it could readily be woven into a cloth or compressed into sheets, and thus perhaps solve the problem of an inorganic flexible insulating material. Perhaps some one will be fortunate in discovering some other fibrous inorganic material which will serve this end.

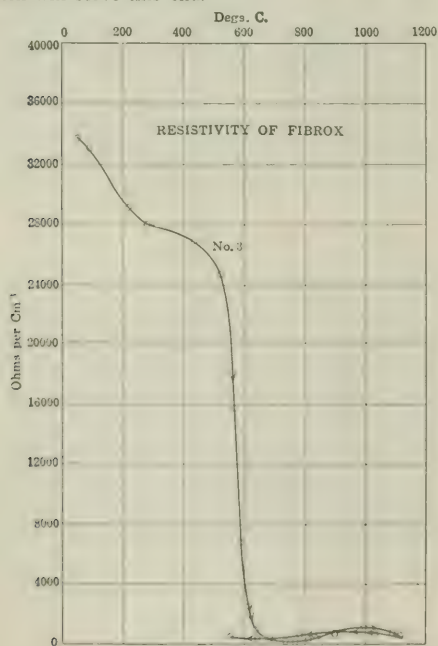


FIG. 2—PLOT OF CURVE NO. 2 ON SMALLER SCALE

In the first determination the lowest resistance read was 1.5 ohms at 760 deg. C., corresponding to a resistivity of 169 ohms, with corresponding figures in the second determination of 0.35 ohm for resistance at 742 deg. C., corresponding to a resistivity of 79 ohms. The question was asked, does the current flow through this low resistance as a result of a chemical dissociation or is the conduction electronic as in metals? If the former were true, it seemed natural to suppose that if a slab of fibrox were clamped between a slab of graphite and a slab of iron (or other metal) that the combination might form a truly *dry* cell which would develop an emf. and yield a not insignificant electric current.

To test this matter two pieces of fibrox (two pieces used in the previous tests) were clamped between two slabs of graphite with a piece of sheet steel between the two sheets of fibrox. The sheet steel was made one terminal and the graphite clamps the other terminal. This combination was lowered into the furnace and the temperature was slowly raised until the sheet steel melted. The two terminals were joined to a potentiometer and a development of an emf. was looked for. It was found that the combination developed a few microvolts only which were referred to thermal emfs.

There was no evidence that fibrox at any temperature under the melting temperature of Bessemer steel (about 1300 deg. C.) acts as does the electrolyte in a cell. The sample was examined after the furnace cooled. The fibrox was black in color, being discolored by the carbonaceous atmosphere, but there was no chemical action between the steel and the fibrox, although the steel slab with which the two pieces were in contact had been partially melted.

May it not be possible, however, to find materials which are non-conductors at ordinary temperatures, but good conductors at high temperatures, and which would form good "dry electrolytes"? For example, MgO in the presence of carbon is decomposed in the hot zone of a furnace, the magnesium vapor recombining with O in the cooler zones of the furnace. May it not be possible to cause this decomposition to take place under high-temperature conditions whereby an electric current could be obtained at the expense of the consumption of carbon?

The Electrolytic Recovery of Lead from Brine Leaches*

By Clarence E. Sims and Oliver C. Ralston

INTRODUCTION AND HISTORY

The knowledge that lead sulphate and lead chloride are soluble in a strong brine solution and that lead may be recovered from such a brine solution by electrolysis is not new, although certainly not widespread. In fact, as long ago as 1854, M. M. Bequerel, of Paris, reported in *Comptes rendus*, 38, 1095 (1854), of the work he had done on lead leaching and electrolysis. In all he treated about 20,000 lb. of ore, mostly from South American and Mexican sources. His method of procedure was to give the ore a sulphatizing roast in the presence of salt and leach out the lead sulphate and silver chloride with saturated brine. The brine was then electrolyzed to recover the metals. The principles of his process were quite similar to those of the process described in this paper. However, Bequerel could never have made his process commercially practical be-

*A paper presented at the New York meeting of the American Electrochemical Society. Contributed by the Department of Metallurgical Research of the University of Utah, in co-operation with the U. S. Bureau of Mines. Published by permission of the Director of the U. S. Bureau of Mines. Mr. Clarence E. Sims is a Fellow, Department of Metallurgical Research, University of Utah. Mr. Oliver C. Ralston is Assistant Metallurgist, U. S. Bureau of Mines.

cause of the then existing commercial conditions, which are much changed now. For instance, he obtained his current from the only source he knew of, namely the primary cell.

H. R. Ellis claims to have developed, in 1893, a process for leaching oxidized ores of lead with a hot (but not saturated) brine containing some copper sulphate. Mr. Theodore P. Holt, at the mill of the Mines Operating Co., at Park City, Utah, found that, on giving his ore a chloridizing roast and leaching with a 20 per cent salt solution, lead built up in the brine to about 8 lb. (3.6 kg.) per ton of solution. At the Bunker Hill and Sullivan mill, at Kellogg, Idaho, a lead sulphide ore, which could not be successfully concentrated, was given a chloridizing roast and leached with brine, with good results.

However, we believe that Neil C. Christensen was the first one, since Becquerel did his work, to conceive the idea of recovering lead from the brine by electrolysis. His work was done in the Knight-Christensen mill at Silver City, Utah. He had been rather successful in recovering lead in this manner on a laboratory scale, and was taking steps to enlarge his experimental plant, when the mill burned down.

The following work was carried out in the laboratories of the Department of Metallurgical Research of the University of Utah, in co-operation with the U. S. Bureau of Mines, and was undertaken for the purpose of finding a commercially feasible process for the recovery of the values contained in low-grade lead ores, which, for any reason, cannot be recovered by concentration processes of any kind.

METHOD OF EXPERIMENTAL PROCEDURE

The Process. In order to take advantage of the fact that both the sulphate and the chloride of lead will dissolve in a saturated salt solution, carbonate ores of lead were treated with brines containing at least enough sulphuric acid to convert the lead to one of the soluble forms. The sulphide ores of lead were given a sulphate roast, which converted 75 to 99 per cent of the lead to the sulphate form and the rest to the oxide form. Enough sulphuric acid was added to the brines to convert this oxide to a soluble form. These leaching solutions were electrolyzed to recover metallic lead. Various details covering the leaching of lead ores by the use of brines will be published later, the present paper being designed to present an exposition of the necessary conditions for recovering lead by electrolysis of the solutions.

Leaching. The leaching was done in 2-liter acid bottles. Four bottles were used, 8 liters of solution being required in all runs. The ore and brine were put together in the bottles with enough sulphuric acid

to convert all of the lead to sulphate of lead. The bottles were then tightly stoppered and agitated on the rolls, usually from two to five hours, although at times leaches were allowed to run over night. When small amounts of CO_2 were formed, owing to the action of the acid, the stoppers were removed from time to time to relieve the gas pressure. But in ores containing large amounts of carbonate, just enough brine was put in with the ore so that the brine would not run out of the bottle when lying on its side unstoppered. Then acid was put in and the bottle later filled with saturated brine and put back on the rolls for leaching.

The filtering was done in an 8-in. Buchner funnel, using a water suction pump. After the pulp had been drained as thoroughly as possible by this means it was washed with barren brine and then with water. The wash with brine must be given first in order to prevent the reprecipitation of the lead in the ore, because the pregnant brine on being diluted with water precipitates lead chloride. The water wash is to recover the salt in the ore.

Electrolysis. The electrolysis was carried out in a 6.5 x 9 x 12-in. (15 x 23 x 30-cm.) storage battery jar, which holds conveniently 8 liters of electrolyte. The accompanying sketch shows the arrangement of the cell in detail. The electrodes were 6 in. square and were hung by strips over heavy copper wire busbars. The anode, except in the case of the insoluble anode, was of 1/16-in. (1.6 mm.) sheet iron and the cathode of 1/8-in. (3.2 mm.) sheet lead. The cathode and anode were both soldered to the busbars to afford better connection. The insoluble anode was of 3/8-in. (9.6 mm.) carbon. Agitation and circulation of the solution was secured by means of compressed air, which was bubbled up between the plates through holes in the glass tube shown in the sketch. A 0-3, 0-15, 0-30 Weston ammeter and a 0-3, 0-15, 0-150 Weston voltmeter were used for measurements, and a slide wire resistance to regulate the current. As a source of current, two batteries consisting of three 15-amp. storage cells, each, were available.

The lead was deposited as a sponge and was allowed to fall off of the cathode and collect in the bottom of the cell to be recovered later. The free evolution of hydrogen near the end of a run was taken as an indication that the solution was depleted of lead and electrolysis was stopped.

The sponge lead was collected by draining or filtering off the solution in a small Buchner funnel. While in the funnel it was washed several times, sometimes with hot water, and at times a little acid was added to the first wash. The sponge was then pressed to remove most of the water, after which it was quickly dried on the hot plate. In melting it down to solid lead it was placed in a fire-clay or iron crucible with a light cover of charcoal (to maintain a reducing atmosphere) and heated over a gas flame or in a muffle. Samples of the electrolyte were taken with a pipette while the electrolyte was being agitated. Lead analyses were run by the chromate method according to Low. Iron was determined by permanganate titration, both zinc and stannous chloride being used at different times for reduction. Zinc was determined by titration with ferrocyanide. Sulphur was determined gravimetrically by precipitation as barium sulphate.

As a rule, the production of sponge metal in the electrolysis of metal-bearing solutions is to be avoided, due to the fact that most metals, when in the form of sponge, are melted down into bars with great difficulty. It is almost an impossibility to melt down zinc sponge. In the case of the lead sponge, the lead not being an especially active metal, and having a low melting point

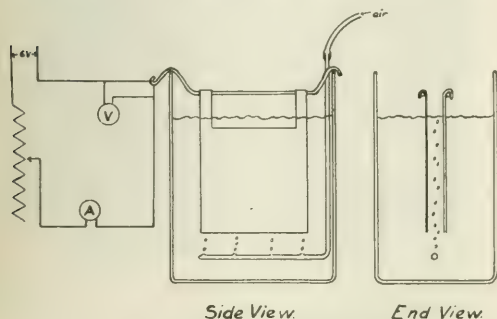


FIG. 1—EXPERIMENTAL ELECTROLYTIC CELL

and as its oxide is easily reduced, the difficulty anticipated did not materialize. In this way electrolysis is not handicapped by the attempt to form reguline deposits of lead.

EFFECT OF CYCLIC RUNS

In starting the series of cyclic runs 8 liters of saturated brine were used. After agitation with ore the brine was filtered off and was then electrolyzed until nearly depleted of lead. It was then run back onto fresh ore for another leach, thus completing one cycle. Enough fresh brine was added to each cycle to replace that lost by evaporation, etc., and to keep the volume of solution up to 8 liters.

Iron builds up slowly in the solution with each cycle until it reaches the neighborhood of 1.5 per cent, when it seems to approach equilibrium. As an amount of iron equivalent to the amount of lead precipitated enters the solution during each electrolysis, then iron must also be thrown out of solution during each cycle. Analysis before and after a leach shows that it is left in the ore. As the leaching solution, although acid at the start, becomes neutral before the end of each agitation with ore, the iron is probably hydrolyzed to either the hydroxide or to a basic chloride. When the electrolysis of the solution has been completed, most of the iron is present as ferrous iron, and it is obviously only the ferric iron which is precipitated. However, it is possible in a neutral solution for the ferrous chloride to oxidize to a basic ferric chloride.

When zinc is present in soluble form in the ore, it goes into solution to a small extent. While zinc sulphate is known to be soluble up to at least 10 per cent of zinc in brine solution, the zinc always remained below 1 per cent in the tests above mentioned.

Sulphates build up slowly and steadily at first. The sulphur is, of course, present largely as sodium sulphate, formed by the double decomposition of the salt and the lead sulphate, when the latter goes into solution. Sodium sulphate is only slightly soluble in saturated brine, however, and readily crystallizes out when present in an amount equivalent to less than 1 per cent of sulphur. Sodium sulphate is different from other impurities in that it is desirable in small amounts, due to the fact that it increases the solubility of lead sulphate in brine. The solution of salt and sodium sulphate, having the maximum solubility for lead, contains about 0.6 per cent sulphur.

Aside from the effect of the sodium sulphate, the solubility of lead in the brine is unaffected by cyclic runs except by lowering the chlorine content.

The cathode efficiency is slightly higher in new brine than it is after impurities have built up in the brine solution. The difference between the cathode efficiency in an old and a new brine is shown in the set of curves in Fig. 2. The cause for the dropping off in efficiency was not definitely determined, although the presence of iron is probably the chief reason, being oxidized from ferrous to ferric iron at the anode, and reduced to ferrous at the cathode. A search for other causes yielded no results.

GENERAL RESULTS

The saturated brine, after agitation with ore, contained from 1.0 per cent to 1.4 per cent of lead. With proper amounts of ore and brine, and enough acid to convert the lead carbonate or oxide to sulphate, the pregnant brine at room temperature will average 1.25 per cent lead. Under these conditions nearly all of the lead, that is, lead in an oxidized form, will be extracted. A typical example is as follows: Starting with an ore containing 8.86 per cent lead, one leach extracted 71 per cent of the lead. By giving these tailings another

leach with barren brine, a 95 per cent extraction was obtained. Counter current leaching always gave about a 95 per cent extraction of the lead.

The current densities it was possible to use were surprisingly large, considering the very low concentration of lead in the electrolyte. That these current densities were not excessive is shown by the fact that with a current density of 80 amp. per square foot (860 amp. per square millimeter) and a lead concentration of 0.4 to 0.6 per cent, a cathode efficiency of 80 per cent was possible; with a current density of 60 amp. per square foot (645 amp. per square millimeter) and a lead concentration of 1 per cent, a cathode efficiency of approximately 100 per cent was obtained. The set of curves in Fig. 3 shows the relation between lead concentration and cathode efficiency for four different current densities. When the current density goes much above 60 amp. per square foot a great deal of hydrogen is evolved from the cathode. Hydrogen is also evolved at lower current densities when the lead tenor of the electrolyte becomes very low.

By referring to the set of curves in Fig. 3, we find that the best current density at which to start an electrolysis is 60 amp. per square foot. This should be maintained until the lead tenor falls to about 0.7 per cent, and then it should be dropped to 40 amp. per square foot (430 amp. per square millimeter). When 0.3 per cent of lead is reached the current density should be dropped to 20 amp. per square foot (215 amp. per square millimeter), and electrolysis stopped when

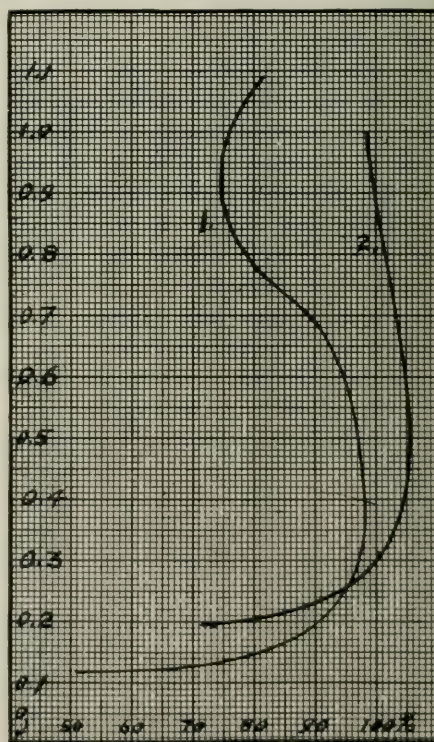


FIG. 2.

Showing the relation between the curves obtained from pure and impure electrolytes.

Abscissa, cathode efficiency in per cent. Ordinates, concentration of Pb.

No. 1. Curve obtained from impure electrolyte.

No. 2. Curve obtained from pure electrolyte.

the lead content falls to 0.1 per cent. The cathode efficiency will vary in two different runs having conditions as nearly alike as possible. One unexplained phenomenon is that the cathode efficiency was always lower at the beginning of an electrolysis than it was a little later in the run. This was also true if the electrolysis was stopped in the middle of a run and started again after an interval of time. It was thought at first that the ferric iron being reduced to ferrous iron at the beginning of the run was the cause of the low efficiency at the start, but it was found that the same thing occurred when no iron was present in the electrolyte. The cathode efficiencies on the whole are encouragingly high. In fact, during the greater part of most of the runs in which 40 amp. per square foot or less were used the cathode efficiency was somewhat over 100 per cent, averaging about 104 per cent. These results may have been due to errors, but the work was carefully done, time measurements and current measurements being proved accurate and check samples being taken for analysis in each case. These results, therefore, compare very favorably with those obtained by Norman M. Bell, who found mono-valent lead dissolving from a lead anode during an electrolysis. (See Trans. Faraday Soc., 11, 79-90, 1915.)

The voltage was very low, the average voltage for different current densities being as follows:

Current Density		Voltage
amp. sq. ft.	amp. sq. m.	
80	850	1.2
60	645	1.0
40	430	0.7
20	215	0.5

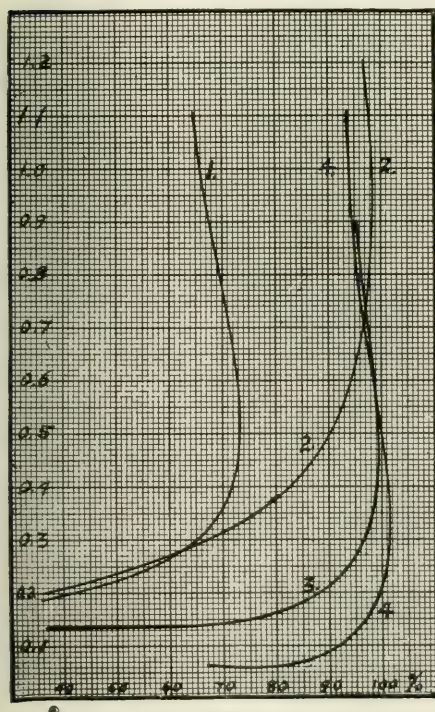


FIG. 3

Showing the relation between cathode efficiency and concentration of lead in the electrolyte at different current densities.

Abscissa, efficiency in per cent. Ordinates, concentration of Pb.
Curve No. 1. At a current density of 80 amp. per square foot.
Curve No. 2. At a current density of 60 amp. per square foot.
Curve No. 3. At a current density of 40 amp. per square foot.
Curve No. 4. At a current density of 20 amp. per square foot.

The cause of the low voltage is evident. The solution tension for iron is 0.42 volt and that of lead 0.12 volt as compared with zero for hydrogen. Therefore, the anodic solution of iron gives more energy than is necessary to precipitate lead cathodically. In fact, there is an initial voltage of 0.1 volt across the electrolytic cell before the external voltage is impressed. As no gas is formed there is no overvoltage of hydrogen or oxygen. Therefore, the impressed voltage is needed only to overcome the resistance of the electrolyte.

Owing to the high cathode efficiency, low voltage, and high electrochemical equivalent of lead, the power consumption per pound of lead is very low. With a current density of 20 amp. per square foot, which means a voltage of 0.5 volt and a cathode efficiency of 100 per cent, as much as 17 lb. (7.7 kg.) of lead per K. W. H. may be deposited. This weight of deposited material is not even approached in the electrolysis of any other metal.

In one set of tests five electrodes were connected in series the same as in the copper series refining process, that is, the intermediate electrodes served as both anode and cathode on opposite sides. The comparison of series with multiple connections is as follows:

At a current density of 60 amp. per square foot:

	Series	Multiple
Cathode efficiency	62.3%	95%
Lead per K. W. H.	4.59 lb. (2.1 kg.)	6.83 lb. (3.1 kg.)

At a current density of 40 amp. per square foot:

	Series	Multiple
Cathode efficiency	68.9%	95%
Lead per K. W. H.	7.83 lb. (3.6 kg.)	8.65 lb. (3.9 kg.)

At a current density of 20 amp. per square foot:

	Series	Multiple
Cathode efficiency	63.2%	100%
Lead per K. W. H.	12.7 lb. (5.8 kg.)	16.1 lb. (7.3 kg.)

In the series connections of the electrodes neither the cathode efficiency nor the power efficiency is as high as in the multiple connections. The advantage obtained by the series connections, from a commercial standpoint, is: (1) a saving of the space taken up by the cathodes and a saving of the cost of the cathodes, and (2) smaller busbars because of the higher voltage and lower current required. On the other hand, the cathodes and busbars are permanent, and it would be only the first cost of installation that would be higher in the case of the multiple connections, while running cost would be lower because (1) more lead would be obtained per K. W. H., and (2) the cathode efficiency being higher the ratio between the amount of iron consumed and the lead deposited would be greater.

The trials with the insoluble carbon anodes gave very poor results. In the first place the voltage was high. There are two causes for the increase in voltage over that obtained with the iron anodes. First, there is no energy obtained by anodic solution, and, second, there is the high overvoltage of the chlorine on the carbon anode. The voltages were as follows:

Current Density	Voltage
amp. sq. ft.	
80	1.2
60	1.0
40	0.7
20	0.5

The cathode efficiency near the beginning of the run was around 70 per cent, but fell rapidly. The brine absorbed large quantities of chlorine and became colored a dark greenish-yellow. This dissolved chlorine attacked the deposited lead sponge chemically and dissolved it nearly as fast as it was being deposited.

The deposit of lead sponge is much more compact and more easily recovered when deposited at a lower current density. When a very high current density is employed the lead sponge is fluffy, and being filled with bubbles of hydrogen it floats on the surface of the

electrolyte. It was also noticed that when the electrolyte was slightly acid rather than neutral that the lead sponge assumed a loose crystalline structure, in which form it could be more easily washed, could be dried more quickly with less oxidation, and could be melted down more readily.

Silver follows the lead in electrolysis. When treating an argentiferous ore from the Horn Silver Mine of Frisco, Utah, some of the lead sponge assayed over 100 oz. of silver per ton. This silver could be recovered from the lead by Parke's process, or could be recovered from the solution before electrolysis by precipitation on sponge lead or on iron. A sample of lead obtained from some calcined tailings, after being melted and cast into an ingot, was sent to the U. S. S. R. & M. Co. smelter at Midvale. The chemist there analyzed it and reported negligible impurities. It seems, therefore, that silver is the only substance of any importance that remains with the lead through the melting down treatment. Because of the very pure lead obtained it would probably be best to remove the silver before electrolysis and so avoid desilverizing the lead bullion.

ESTIMATED COSTS

The accompanying sketch of a commercial size electrolytic cell shows how one might be built for the electrolysis of the brine solutions of lead. On a cell of this design, the electrodes may be connected either in series or multiple. The drawing shows the arrangement for multiple connections. The arrangement for connecting in series would be the same except that the cathodes would be absent, and instead of having busbars down the sides, only the end plates would be connected with the external circuit. The pregnant solution would flow into one end from a feed launder and overflow at the other into a discharge launder. Agitation would be by air from holes in the six pipes running along under the electrodes. The sponge falling off of the plates would collect in the center of the V bottom and be carried to one end by the screw conveyor and then be discharged through the hopper arrangement along with a small amount of barren solution.

Because of the very high current densities used the multiple connections are out of the question, owing to the immense size of busbars that would be necessary. Therefore, estimates and calculations will be made on a process using a cell in which the electrodes are connected in series.

Following is an estimated cost of the erection of an electrolytic plant, exclusive of the leaching plant, to produce 10 tons of pure lead per day.

It will be noticed that a margin of from 10 to 20 per cent excess is allowed on all estimates above calculated figures.

In an electrolytic cell such as is shown, using series connections, forty-one electrodes may be used. The electrodes being 3 ft. square, there will be $3 \times 3 \times 40 = 360$ sq. ft. (33.5 sq. m.) of cathode surface. Using a current density of 40 amp. per square foot (430 amp. per square millimeter), which is conservative, and from

data obtained assuming a cathode efficiency of 70 per cent, we have:

$$\frac{360 \times 40 \times 0.70 \times 103.5}{96,500 \times 1000} = 38.6 \text{ kg. per tank per hour.}$$

$$38.6 \text{ kg.} = 85 \text{ lb. per tank per hour.}$$

$$85 \times 24 = 2040 \text{ lb., or 1 ton per tank per day.}$$

Therefore, ten tanks would produce 10 tons lead per day.

The drop between electrodes will be about 0.7 volt. $0.7 \times 40 = 28$ volts. 40 volts will be allowed for each tank.

$$40 \times 10 = 400 \text{ volts for ten tanks.}$$

Therefore, figures will be made for a 450-volt generator to deliver 400 amp., 360 amp. being needed.

$$\frac{400 \times 450}{1000} = 180 \text{ kw.}$$

A 200-kw. motor-generator set will therefore be needed. The excess power would be used in compressing air, operating pumps, etc.

By empirical measurement it was found that about 0.5 cu. ft. of air per minute is necessary for a 3-ft. length of electrode in order to give sufficient stirring of the electrolyte. Therefore, $40 \times 0.5 \times 10 = 200$ cu. ft. of air would be required per minute for all of the tanks. 300 cu. ft. will be supplied.

Knowing the size and amount of equipment the estimated cost would be as follows:

One 200-K. W. motor-generator set, 450-volt, 400 ampere..	\$3,500
One 200-K. W. transformer, 45,000 to 560 volts.....	2,100
Ten wooden tanks at \$100 per board foot, including construction, \$50 apiece.....	500
Copper bus-bars, 0.5 inch in diameter, 100 ft., 64-lb. per 100 ft., at \$0.30 per lb.....	30
Piping, 800 ft. at \$0.165 per ft.....	130
Launder.....	100
Positive pressure blower, 300 cu. ft., at 3 lb.....	420
Motor for blower, 25 H. P.....	350
Small reverberatory for melting down 10 tons lead per day.....	500
Lower plant building, \$5 per sq. ft.....	3,000
Electrolytic plant building, \$2 per sq. ft.....	4,000
Miscellaneous equipment.....	2,000
Total cost, erected.....	\$16,630

Costs of the leaching plant are not included in the above total, but have been variously estimated from \$10,000 to \$15,000, including crushing equipment and housing. In case a sulphide ore is being treated, the cost of roasters will also have to be considered.

OPERATING COSTS

For operating costs, the following figures are approximate. They are made on the assumption that the material used is a mill tailing containing 10 per cent lead in an oxidized form. The iron anodes are assumed to consist of cast iron, 1 in. in thickness:

Leaching ^a hundred tons at \$9.50 per ton (for Horn Silver Mine ore)	\$80
Iron (estimating that 1 lb. iron is used for every 3 lb. lead deposited, and that it costs \$40 per ton in anode plates), 3.3 tons.....	132
Power, 200 K. W. at 0.6c per K. W. lb.....	35
Labor, one foreman and four helpers on each of three shifts..	57
Coal, 1 ton per day.....	3
Insurance and interest.....	20
Total for ten tons lead in one day.....	\$330
Cost of producing one ton lead.....	33
Value ^a of one ton lead at 2 3/4c. lb.....	55
Estimated margin of profit.....	\$22

CONCLUSIONS

The investigation on the electrolysis of lead in brine solutions is by no means complete. In the experimental work there is still a great deal to be learned about the

^aThe leaching cost is calculated from the known acid requirements of a certain ore which contains a large amount of lead sulphate and only a small amount of lead carbonate. For most ores more acid would be required and hence the leaching cost would be higher.

^bIt will be noticed that the value of the lead is calculated on a 2 3/4c. per lb. basis. This is for the reason that in Utah, where this process has been developed, the cost of transportation to lead markets and refining is 1 1/4c. per lb. Hence our estimate really assumes a 4c. market. As a very pure lead can be obtained it is probable that only transportation costs need be considered, thus materially increasing possible profits.

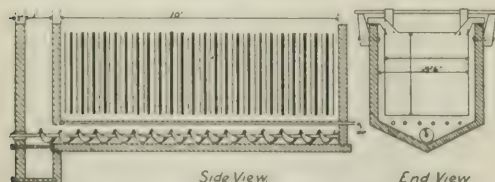


FIG. 4—COMMERCIAL SIZE ELECTROLYTIC CELL

causes of low cathode efficiencies; how the iron is thrown out of solution, conditions for obtaining the maximum concentration of lead with the smallest acid consumption, etc. The working details of a commercial plant have not been thoroughly worked out.

It would seem at first that it would not be possible to profitably electrolyze a metal of as low a value as lead. But when one considers the cheapness of the leaching agent and the high electrochemical equivalent of lead, together with the wonderfully high efficiencies possible, the problem assumes a different aspect.

If the process should be applied to mill tailings or a mine dump it looks as if a fair profit might be made. However, considering the low value of the product obtained, a 10 per cent material could not be worked if a mining charge of several dollars a ton were added to the cost, although a lead carbonate deposit near the surface could stand considerable of a mining charge if a 15 to 20 per cent ore were obtained.

Although electrolytic precipitation of the lead from brine-leaching solutions is the principal subject discussed in this paper, the Department of Metallurgical Research of the University of Utah, in co-operation with the U. S. Bureau of Mines, has likewise been testing other methods of precipitation, and modified methods of leaching. We believe that such a method of treating lead ores will be found applicable to those ores at points distant from lead smelters, which are too low grade to ship, and which for any reason refuse to yield, as before stated, to gravity concentration. Many lead carbonate ores are of this type.

Salt Lake City, Utah.

Synopsis of Recent Chemical and Metallurgical Literature

Carbolic Acid Manufacture in Germany.—A method for recovering carbolic oil from coal tar and some data on carbolic acid in Germany were given in a recent article by Dr. F. RASCHIG, in *Zeitschrift für Angewandte Chemie*, and abstracted in the *Chemical Trade Journal*. Dr. Raschig says that before the war the carbolic-acid requirements of Germany were met for the most part by the importation from England of crude carbolic acid, which was worked up into pure products in Germany. Germany was dependent upon foreign crude material because English tars are extraordinarily rich in carbolic acid and are obtained in ample quantities, while German tars are poor in carbolic acid, and, until the end of last century, small in production—not one-third of the tar production of Great Britain. The war cut off English supplies of crude carbolic, and also increased Germany's requirements. There is, says Dr. Raschig, an appreciable shortage of carbolic acid in Germany, and he adds the opinion that "the shortage will become more pronounced after the conclusion of peace, when the foreigner will again have access to us, and the large orders which were formerly placed in Germany will be renewed."

Dr. Raschig describes how a carbolic oil containing from 25 to 30 per cent of phenols can be prepared, and mentions that factories for the extraction of these from the oil are in existence or will shortly be erected, to which he suggests the smaller tar distilleries should send their oil. The starting point in the process for producing this carbolic oil is the middle oil of the tar distillation, the fraction coming over at about 170 deg. to 250 deg. C. After separation of about half of the naphthalene content the fraction is again distilled under vacuum. An oil which boils at 170 deg. to 200 deg. C. under atmospheric pressure distills at about 100 deg. to 120 deg. under vacuum, and therefore the apparatus

can be heated by indirect steam at a pressure of 6 to 8 atmospheres. In this way a constant source of heat is obtained, and the distillation proceeds uniformly, independently of the personal equation of the operator. In the ordinary way of vacuum distillation, samples cannot be collected at the moment of coming over, but with the vacuum method devised by Dr. Raschig the distillate is collected in the open, and can be sampled as it comes. Vacuum working necessitates the condenser being placed at least 12 metres (about 39 ft.) above the boiler, and the use of a fall tube of equal length. A special fractionating column designed by Dr. Raschig is also employed, and this he uses as much as 14 metres (about 45½ ft.) in height.

Dr. Raschig claims that German gasworks tar and coke-oven tar could yield annually about 6,000 tons of crystallised carbolic acid, as against scarcely 2,000 tons now obtained. He adds that Germany can produce a quantity of synthetic phenol, but this process requires large quantities of benzene and sulphuric acid, both of which can at present be more usefully employed for other purposes.

Device for Premelting Ferromanganese.—An interesting device for premelting ferroalloys shown in Fig. 1 was described in *Iron and Coal Trades Review*, Aug. 25, 1916. It comprises a melting compartment, built as an extension to the back wall of the furnace, in which ferromanganese and other final additions are melted by the heat of the furnace. Referring to the

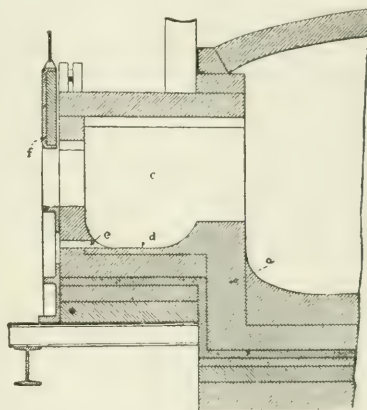


FIG. 1—CROSS SECTION OF AN OPEN-HEARTH FURNACE, SHOWING THE ADDITIONAL CHAMBER FOR PREMELTING FERRO-ALLOYS

illustration, *a* is the back wall of a furnace, against which, and preferably adjacent to the top hole is the chamber *c* open to the interior of the furnace. It has a melting hearth *d* and a tap hole *e*, and is closed by sliding door *f*.

The final additions, such as ferromanganese, ferro-silicon, spiegeleisen, ferrochrome, etc. are charged through this door and are melted by the heat of the furnace. The device is patented by Messrs. Wheeler & Blair (England).

Corrosion of Tinned Sheet Copper.—In a paper presented at the annual meeting of the American Institute of Metals at Cleveland in September, PAUL D. MERICA described an investigation of a curious case of corrosion of tinned sheet copper which formed part of the roof of the Library of Congress in Washington. (A fuller account of the investigation will be published as

a Circular of the Bureau of Standards.) The greater part of the roof of the Library is covered with tinned sheet copper which was installed in 1894. The sheet is 16 oz. tinned on both sides and lies on cement or terra-cotta.

The lower or under side of this sheet has become but little altered in the course of time, except that it has become blackened at the points where the sheet is perforated by the holes described below. The upper or exposed side has taken for the most part, a dark, slightly greenish patina, which is dense and coherent, although in some areas there is a whitish tinge due to the tin or tin oxide. On this surface are found in fairly dense distribution, small pits or furrows, of which the diameter or width varies from 1/32 to 1/64 in., the furrows being sometimes as much as 2 inches long. In many sheets there will be as many as 100 per sq. ft., in others, much fewer; often these pits extend completely through the sheet as perforations, through which leakage takes place. The edges of these pits are exceedingly sharp and well defined, much more so than the photograph indicates; their inside surfaces are sometimes covered with a thin reddish or black layer of copper oxide, often, also, with a thin green layer, which is probably basic copper carbonate. It was stated that they had first been noticed some 8 or 10 years after completion of the roof.

A preliminary examination and chemical analysis of the material from the roof of the Library of Congress (B. S. No. 1054) showed that the tin coating contained:

Tin	89.5 per cent	Lead	8.0 per cent
Iron	1.0 per cent	Zinc	1.5 per cent

In order to study the structure of the coating, the sheet was first copper plated on both sides, and then mounted in plaster of Paris (sometimes also in solder). Specimens also were bent slightly, ground and polished on the convex side through both the protecting copper plate and the coating; such a section will be called an oblique surface section. Etchings to develop the structure was done successively with an ammoniacal solution of copper ammonium chloride and with a hydrochloric acid solution of ferric chloride.

The conclusions drawn from the experiments were as follows:

"The explanation of the local character of the corrosion of the tinned sheet copper roofing material seems, therefore, fairly clear. Along the line of scratches, tool marks, etc., the thin coating of tin (thickness, about 0.012 mm. in average) was penetrated and the copper underneath exposed. This copper is in contact with an alloy layer, which is proved to be electro-negative, and less readily corrodible, than the copper; at these points the copper and the alloy layer form a galvanic couple, the copper being attacked more readily than if the alloy were not there.

"It therefore appears that this type of corrosion is possible, inherently, in any sample of tinned copper, since the present process of tinning always produces this intermediate layer of alloy, which acts as an accelerator of corrosion, once the underlying copper is exposed. Many instances are on record, however, of material exactly similar to that described above, which has been in service for 25 and 30 years under much more severe service conditions than those of the Library of Congress, and which has not shown signs of such pitting. Explanation of the variation of resistance to local corrosion of different samples of the same type of material must be sought in the variation of the amount of mechanical abuse given it in service, such as the scratching of the surface, etc., and in the matter of the uniformity in thickness and structure of the tin coating. It was noted that the protecting layer

of eutectic was of quite variable thickness in the sample 1054, and that there were often breaks in the continuity of both the alloy and the eutectic layer, which would also aid in accounting for the initial penetration of the coating.

"The presence of the small amounts of iron and zinc in the coating must also not be lost sight of in this connection; it is possible, although it has not yet been possible to prove, that the presence of these impurities may have contributed toward the initial corrosion of the coating, exposing the copper underneath.

British Dyestuff Manufacture.—The progress of the dyestuff industry in England is described in the recent directors' and managers' reports of British Dyes, Ltd. (Published in the *Chemical Trade Journal and Chemical Engineer*.) It contains considerable matter of interest to dyestuff manufacturers in this country.

The issued share and loan capital of the company consisted as at Aug. 1, 1916, of: Share capital subscribed (864,179 shares of £1 each—10s. per share called up), £864,179; loan from government, £1,064,179; making a total of £1,928,358. Since the date of the report submitted to the statutory meeting of the company (July 5, 1915), the subscribed share capital has increased by £208,080, and the loan to which the company is entitled from the government has increased by £209,629, making together an increase of £417,709.

The Board of Directors have established:

(1.) *A Committee of Directors.* This committee gives continuous attention to the affairs of the company.

(2.) *A Technical Committee.* This committee combines the heads of the technical and scientific departments with Dr. Forster as chairman.

(3.) *A Research Department,* of which Prof. W. H. Perkin is the head. On account of the delay and expense which would have been involved in erecting during the war a central research laboratory it has been arranged that in the meantime the research work, so far as not conducted in the works laboratories, should be carried on in the laboratories of different universities under the supervision of the professors of organic chemistry. Research colonies have been established in this way employing a number of assistants under the respective professors, and much important work is being carried out.

(4.) *An Advisory Council,* which consists of twelve eminent professors of chemistry connected with different universities in addition to the members of the Technical Committee. It has been formed for the purpose of increasing the number of chemists and promoting research in organic chemistry, and particularly in that branch of it which relates to coal-tar colors. The company has offered to place at the disposal of the professors an annual grant for the remuneration of honor graduates in chemistry who have received special instruction in coal-tar products and who are prepared to continue their training as research assistants. After such training the company will be prepared to offer employment to suitable men recommended by the professors. The directors have also agreed to make a grant of £5,000 towards a scheme for the development of advanced teaching and research in tinctorial chemistry in the Technical College at Huddersfield.

Notwithstanding the restriction caused by the shortage of certain materials owing to the war, the supply of dyes from the company's works has been greatly increased. New plant has been erected and is in course of erection for further increasing the supply of those dyes which are most in demand and which can be made in large quantities from the materials available. In the near future the supply will be further substantially

augmented. The company has also sent to the Swiss manufacturers considerable quantities of raw materials and intermediate products, without which they would not have been able to continue their supplies to the British markets.

A committee appointed by the Board of Trade has made an exhaustive inquiry into the color requirements of this country. Mr. Turner, the manager of the company's works, who represents the company on the committee, has, with the authority of the Board of Directors, submitted proposals for the prevention of overlapping in manufacture and for utilizing the resources of all dye-makers in the country to the fullest advantage.

After conferring with a number of the leading users of dyes, the directors decided, so far as the new works are concerned, to provide in the first place mainly for manufacturing on a large scale raw materials and intermediate products. They desire to call particular attention to two important considerations:

(1.) In order to secure a permanent national supply of dyes it is imperative that the manufacture of the intermediates from which dyes are made should be successfully established in this country.

(2.) The production of these intermediates requires the operation of a series of processes not hitherto worked on a commercial scale in this country, and it also requires complicated and expensive plant.

A large amount of research and experimental work has been done, and a considerable quantity of plant has already been erected for the production of intermediates. Other important plants are in course of construction, including plants for paranitraniline and betanaphthol.

As regards raw materials, the benzole and phenol plant has been largely increased. An acid plant sufficient for the requirements of the company is approaching completion, and a large part of it is in operation.

When the Turnbridge Works of Messrs. Read Holliday & Sons, Ltd., were acquired by the company, considerable extensions were in course of construction by that company, and these have been completed. After careful inquiry with regard to sites elsewhere an additional freehold site, extending to 343 acres was acquired at Huddersfield. A railway connecting this site with the Turnbridge Works and with the London & North Western Railway has been constructed, which, with its branches and sidings, extends to about eleven miles of single line. Buildings for the accommodation of a large amount of plant have been completed at Turnbridge Works and on the new site. A portion of the new plant has been installed in these buildings, and important materials and products for making dyes are being obtained from it, including a supply of the acids required. A large amount of additional plant is in course of manufacture and erection. A new works laboratory has been completed at the Turnbridge Works, and a oratories will give suitable accommodation to the staff second, including provision for large-scale experiments, is approaching completion on the new site. These laboratories of chemists, which has been largely increased. Works and plant for the supply of water, ice, electricity, and steam are in course of construction, and are partly in operation.

The construction of the additional works and plant has been carried on under conditions of special difficulty as regards time and cost on account of the scarcity of the materials and labor required for such work, and of the difficulty in obtaining deliveries of the plant from the makers, and also because a large part of the work was carried out during a winter of exceptional inclemency. Nevertheless, substantial progress has been

made, the total contents of the new buildings erected at the old and new works being not less than 25,000,000 cu. ft. and the floor area covered 1,200,000 super. ft. (about 27 acres.)

The directors propose to arrange for the shareholders to have an opportunity of examining the works.

As the result of conferences with a commission specially appointed by the French government, the board has adjusted a provisional agreement with Le Syndicat National des Matieres Colorantes (a national company which has been formed in France with the support of the French government.) This agreement provides for a complete exchange of knowledge and processes and for the formation of an inter-allied company to establish co-operation between the two companies in regard to the production of intermediates and dyes.

Mr. J. Turner, manager of the company's works, reports as follows:

"During the year the difficulties that we have had to contend with have been very numerous, including shortage of labor and difficulty in getting in machinery and materials, and, in addition, there has been a great shortage of several of the raw materials. Notwithstanding these drawbacks we have been able to make considerable progress.

"During the year we utilized our steamer on several occasions to bring fuming acid from America, not only for our own consumption, but also for consumption by the other color makers in the country. This has enabled them and us to get a larger production than we otherwise could have done, and it has also materially helped the supply by enabling us to send materials to Switzerland, in consequence of which the Swiss companies have been able to continue their supplies of dyestuffs to this country.

"The erection of our oleum plant is nearly completed, and a large part of it is in operation. This should alleviate the position for the future and enable us to give a larger output than we are doing at present, and also a greater variety of colors. The plant is a large one, and should be capable of producing all the oleum required by us when it is in full working order. We have also erected an additional nitric acid plant, and a large part of this is in operation.

"We have largely increased our plants for the production of benzol, toluol and phenol, and also for the manufacture of dimethylaniline, and these should be sufficient to supply all our requirements after the war.

"At the beginning of the war our arrangements for producing sulphur colors, both in respect to equipment and raw materials, were totally inadequate to the new needs of the country; it is satisfactory to note, therefore, that we have since increased our output to more than three times the original amount. These colors have rendered real assistance to the British dyeing industry. The enlarged production has enabled users to obtain by new methods, shades such as indigo, which they could not otherwise have obtained, and in some instances mills have been kept running by the substitution of these colors, coupled with the basic colors. Without them it would have been impossible for the country to have produced anything like the variety during the war, and it is reasonable to believe that our increased output has had a beneficial effect in checking the tendency of prices for such colors to rise to an unreasonable level. High prices have been made for some of them in small quantities, but this only tends to show the prices which these colors might have reached but for our increased output.

"Although we have been able to offer a fair supply of direct blacks, the position of a variety of direct

cotton colors has been less satisfactory, owing to the lack of some of the necessary materials, including fuming sulphuric acid. We have been more fortunate in respect to wool colors, however, the necessary brown for dyeing khaki cloth having been provided without difficulty. At one time khaki yellow became rather scarce, but for the last six or eight months the supply has been sufficient to meet the demand, and the same statement applies to khaki green. With respect to the ordinary wool colors, our supply of the fancies has been smaller than our normal deliveries, owing to the limited amount of raw materials available, but our plant for producing these and the necessary direct cotton colors has been increased with a view to taking immediate advantage of the prospective increase in the supply of intermediates.

"We are now manufacturing a color similar to tartrazine, thus checking a further rise in the price of this dyestuff and enabling us to meet the demand. Gallocyanine has also been delivered in satisfactory quantity,

and its process of manufacture will be extended to other colors resembling it.

"Increased facilities for the production of basic colors and patent blue are also planned, and before long we shall manufacture several of the vat colors in small quantities.

"I would direct special attention to the vital importance of the manufacture of the intermediate products. The products from which many dyes are made have not been manufactured in this country on a commercial scale, and a practical knowledge of the processes and plant required for obtaining the best results in respect to them can only be arrived at by investigation and experiment. A considerable amount of work of this nature has been done, and plant for the manufacture of paranitraniline and betanaphthol and other intermediate products is in course of construction. There remains, however, a large amount of work of this nature which is essential to the building up of a national industry."

Second National Exposition of Chemical Industries

Opening Exercises

The Second National Exposition of Chemical Industries, was opened at 2 p. m., Monday, Sept. 25, at the Grand Central Palace. At 2.30 the conference hall where the official opening exercises were to be held was well filled. CHAS. F. ROTH, one of the managers of the exposition, was chairman of the exercises and after a few words of welcome, he introduced the first speaker, Dr. CHAS. H. HERTY, president of the American Chemical Society.

Dr. Herty spoke in his impressive style with a great deal of enthusiasm as follows:

It is an inspiring occasion that brings us together here to-day. In this building are gathered the evidences of the resourcefulness, ingenuity and courage of American chemists and chemical engineers.

The exhibits, more than doubling in number those in the initial exposition last year, furnish ample proof that the unusual call upon the chemists during recent months has been worthily met, and it is an especial pleasure to express to the managers of the exposition our indebtedness for the splendid handling of this increasingly important event.

In addition to the important advances here evidenced in the manufacture of dyestuffs, glass, porcelain and machinery of all sorts for chemical plants, there is a distinct new feature furnished by the inclusion of exhibits of natural resources suited to the development of chemical industries.

I feel that our modest beginning along this line presages a far wider development in the future, and that this exposition will assume naturally, though gradually, its true function; namely, an assemblage of the products of chemical industry and a meeting place for consultation and discussion of manufacturing difficulties, and as an assemblage point for the exhibition of the great natural resources of this country, exhibited from the standpoint of their availability for the development of chemical industries. With this new and widened vision, untold possibilities of great national service present themselves.

The deep and intelligent public interest in the exposition furnishes abundant proof that the people of our country are steadily gaining a clearer idea of the fundamental importance of chemistry to the welfare of the nation.

While the growth of chemical industries during the past year has been marvelous, nevertheless we chemists must bear in mind that, if this growth is to reach its full fruition, co-operation along the broadest lines is absolutely necessary in all of our efforts. Germany has already publicly announced the unification of all the separate establishments of its great dyestuff industry. So, too, have we learned recently of the international co-operation between the chemists of England, France, Russia and Italy. In view of such developments, it behooves us to give the most serious consideration to the question of our policies in the development of the American chemical industry.

Under our national laws combinations are made illegal, and, in the past, the American chemical manufacturer has been characterized by a rather unusual amount of secretive-

ness regarding his operations. Surely the day has arrived for broader policies, in which the forces of this nation can harmoniously work together without sacrificing individuality to the end that the products of American chemical industry, made from our own natural resources, may not only fully supply our domestic needs but may meet in fair competition the products of all other countries in the markets of the world.

This problem of co-ordinated effort is the big problem of this week, and, in its out-working, I urge the loyal and patriotic thoughts of every chemist.

Mr. LAWRENCE ADDICKS, past president of the American Electrochemical Society was the next speaker. He spoke as follows:

It is eminently fitting that a word should be said for electrochemistry on the occasion of this exposition of progress in American chemical industry. This branch of chemistry, which had very modest beginnings on the practical side with the development of primary batteries and electroplating, has grown so rapidly and notably upon American soil that it has had much to do with transforming old-time chemistry into the chemical engineering of to-day, which is fast taking the place held by electrical engineering in the last twenty years as the great field of opportunity. For several centuries the chance for fame and wealth lay chiefly in the exploration and conquest of new lands. Then came the great commercial ventures in shipping and commerce. As experience made this commonplace, men turned to searching out the great mineral deposits in the less known parts of the world. When gold fever died out and the world began to look monotonous, the electrical developments of the last fifty years offered just as sensational work nearer home. And now the era of chemical engineering seems to have fairly arrived.

Electrochemistry has a peculiar responsibility which differentiates it from chemistry proper in that it is the common meeting ground of several hitherto separated sciences each of which overlaps to form some of the most interesting of problems. It is here that the electrical engineer and the chemist first appreciate that the directive influence of electrical energy can not only be used to upset normal chemical affinities, but that the resulting processes offer one of the largest uses for electric power. It is here that the chemist realizes that physics is but a branch of chemistry and the physicist that chemistry is but a branch of physics. Metallurgy finds not alone new tools, but new products. Medicine becomes interested in radioactivity, and, I am sorry to say, law in electrochemical corrosion. In this way electrochemistry has exercised a reuniting influence upon the schisms which have resulted from specialism. In the same way the American Electrochemical Society has brought together men from widely different fields of effort and it is only by breaking down the barriers between science and engineering and creating a compact and comprehensive profession of the entire engineering fraternity that progress in any way commensurate with present opportunity can be made.

The rapid developments of the last year have, of course,

largely been due to the abnormal conditions affecting foreign commerce. Some of our exports have been in great demand, while some of our imports have been absolutely cut off. This has resulted in high values for both classes of materials, giving the needed stimulus for the development of substitutes and the founding of many new industries. And the market is not simply a temporary one, dependent upon war-time conditions. In many cases the investment required has been the only deterrent heretofore; now the investment has been made. Also a product never goes to an abnormal price without permanently losing some fields of application. For example, the high price of copper has surrendered many brass articles to enameled or brass plated iron; in other cases parts, such as ship hardware, have been greatly lightened. Sodium is replacing potassium wherever possible, as in glass, etc., and so on. Then again the actual shortage in certain products has developed processes for refining low-grade material, a notable case being that of electrolytic zinc. These changes are permanent and we find ourselves suddenly carried forward through ten or fifteen years of normal progress in many lines of industrial endeavor, and, what is more, every part of this progress from the scientific research upon which it is based to the source from which the raw material is drawn is American.

The international situation in which we find ourselves has also caused a great awakening throughout the country as to the need of the co-ordination of our industrial resources for national defense, and this has done much toward a mutual understanding in a country where the pendulum has generally swung between bitter competition and monopoly, between which extremes there is little to choose.

We may regard this exposition and the concurrent meeting of three professional societies not only as a demonstration of the accomplishments of the last two years, but as an earnest of what can yet be done.

It is with especial pleasure, therefore, that the Electrochemical Society does its small share in welcoming you to this Exposition of Chemical Industries, which shows what united effort is doing to put this nation at the very front in chemical engineering.

Mr. THOMAS J. KEENAN, secretary of the Technical Section of the Paper and Pulp Association reviewed the progress which has been made in the manufacture of paper during the last fifteen years. He said that the latest census showed the paper industry to be second in importance only to the iron and steel industry. The total invested capital is \$500,000,000, while the value of the annually manufactured products of pulp and paper amounts to \$350,000,000. He showed how important chemistry was to the art of paper making. Promising developments in the southern states, through the application of chemistry to the recovery of paper fibers from waste wood, should be mentioned. Kraft paper is now made from imported pulp to the amount of some 60,000 tons annually. Immense quantities of yellow pine waste lumber are available in Florida, Georgia, Louisiana, and other southern states for the manufacture of pulp by the sulphate process, which yields the strong brown paper called 'kraft.' A beginning in the development of this industry has been made in the South, and it is expected to make us independent of other countries so far as this class of paper is concerned.

Dr. IRA REMSEN of Johns Hopkins University said that he had devoted his life to the science of chemistry but had always been profoundly interested in industrial chemistry. He said that the advancement of industrial chemistry depended upon the advancement of the science of chemistry and that therefore there should be the closest co-operation between the scientists and the industries.

Mr. ADRIAAN NAGELVOORT, one of the exposition managers closed the exercises with a few words about the exposition and with a hearty welcome to the visitors.

The exposition itself was an immense success. It was again managed by Mr. Adrian Nagelvoort and Mr. Charles F. Roth, jointly with the International Exposition Co., with Mr. F. W. Payne at the head.

While last year all the exposition was on the ground floor, it was necessary this time to use also the second

floor. The exposition had practically doubled within a year—in itself a suggestive indication of the rapid progress of American chemical industries. The adjoining illustrations will give an idea of the attractiveness and comprehensiveness of the exhibits. An alphabetical list of the various exhibitors and their chief exhibits follows:

Paul O. Abbé, New York City, exhibited mixers, jar mills, rotary cutting machine, combined sifter and mixer for dry powder, respirators and goggles. Of especial interest was a new mill consisting of 4 small jars and 2 large jars. The small jars run at a higher speed than the large ones. Mr. Abbé was in charge.

Abbé Engineering Co., New York City, exhibited small jar and ball mills in actual operation; a working model of their tube mill with patent "Ideal" spiral feed and discharge with glass end to show method of operation; section of pebble mill showing patent manhole frame with detachable flanges which permits replacing lining plates without calling for new manhole frame. Mr. Henry Kleinfeld was in charge.

H. Reeve Angel & Co., New York City, exhibited their full line of filter papers. Mr. Brothers and Mr. Lenton were in charge.

Alberene Stone Co., New York City, exhibited a complete laboratory installation of bench, gas hood, and sink made of Alberene stone, and samples of the stone cut to various sizes and shapes. Also soap stone linings for pulp furnaces. Photographs of various installations. Messrs. N. N. Money Penny and A. Y. Meeker were in charge.

American Apparatus Corporation, New York City, had a very complete exhibit of general laboratory supplies, among which were Riche Adiabatic Calorimeters, Lenzman Insol glassware, quartz glass, testing machines, vacuum pumps, laboratory furniture, water stills, etc. Of especial interest was a large glass flask of about 50 gals. capacity with walls less than one-sixteenth inch thick. Mr. G. Gruenberg was in charge.

American Chemical Society:—Booth for the use of visitors.

American Coal & By-Products Coke Co., Chicago, Ill.—Diagrammatic drawings in colors of the Roberts method of destructive distillation of coals and method of recovery of by-products, model of fuelless oven, type of wall brick, illustrations of by-product apparatus for the recovery of cyanogen, benzol and the light oil homologues, samples of products recovered. Messrs. Arthur Roberts, H. V. Patterson, and Louis C. Whiton in charge.

American Electrochemical Society displayed an automobile chassis with a dismantled engine showing by means of placards attached to the points in question, what a large part electrochemistry played in its manufacture. "Niagara made Detroit possible." The idea of the exhibit was Mr. Lidbury's. Dr. Schluederberg and Dr. Fink were in charge.

American Institute of Mining Engineers had a booth for the entertainment of visitors.

American Synthetic Color Co., Inc., Stamford, Conn., exhibited intermediates such as phenol, resorcinol, paratrichlor, orthonitrochlor, nigrosine, and others. Mr. C. H. Hazard was in charge.

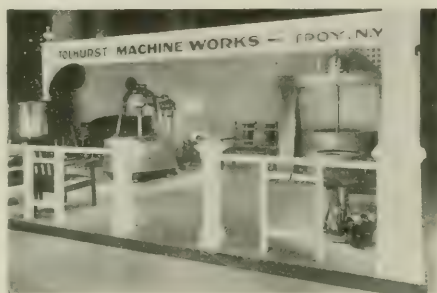
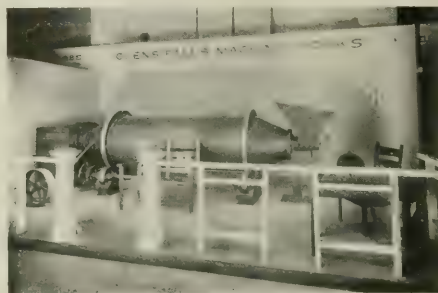
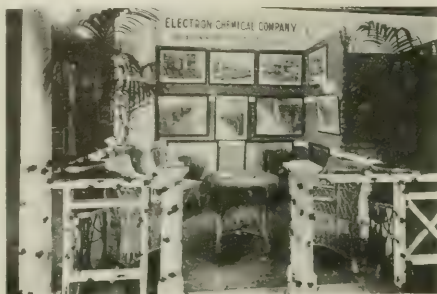
American Transformer Co., Newark, N. J., had an exhibit in conjunction with that of the Research Corporation. They supplied the 100,000-volt transformer for the demonstration of the Cottrell electrical precipitation process. Mr. W. F. Hubley was in charge.

Arnold, Hoffman & Co., New York City, showed the alkaline products of Mathieson Alkali Works, Castner Electrolytic Alkali Works, and Nitrogen Products Co., for which they are the selling agents. They also exhibited the Wallace & Tiernan automatic chlorinator. Messrs. H. H. Hall, A. L. Hays, and J. E. Clancey were in charge.

E. B. Badger & Sons, Boston, Mass., had an exhibit showing drawings and diagrams of their distillation apparatus and Badger-Webre evaporators. Displayed a few pieces of the beaten copper work. Mr. C. L. Campbell was in charge.

J. T. Baker Chemical Co., Phillipsburg, N. J., had an attractive exhibit of Baker's analyzed chemicals neatly arranged in show cases, among which were PCl_3 , PCl_5 , POCO , molybdic acid and ammonium molybdate. Mr. E. C. Baker was in charge.

City of Baltimore, Md., exhibited a miniature reproduction of the city of Baltimore showing harbor and dock facilities, also several photographs of conditions pertaining to feasibility of plant location in that city. Mr. H. Kent McKay was in charge.



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Barber Asphalt Paving Co., Philadelphia, Pa., exhibited a very complete line of preservatives among which were their "Genasco" acid-proof paint, "Genasco" metal preservative, Vulcanite acid-proof mastic, and various types of waterproofing and roofing materials. A demonstration was made of the colloidal aspect of Trinidad asphalt with special attention to the colloidal mineral matter of same. Mr. H. M. Menner was in charge.

The Barrett Company, New York City:—Refined coal tar derivatives and other products manufactured by various companies in which their chemicals had been used. Messrs. H. G. Sidebottom, F. E. Dodge and W. E. Brophy were in charge.

Bausch & Lomb Optical Co., New York City, exhibited their metallurgical microscopes and metallographic instruments, and their Made-in-America optical glass. Messrs. R. C. Dean and A. E. Welti were in charge.

Beach-Russ Company, New York City, showed small sizes of their rotary vacuum pumps and pressure blowers in operation. Their compound dry vacuum pump is guaranteed to produce a vacuum within one-tenth inch of barometer, which was demonstrated by means of a colored water column 34 feet high graduated for both water and mercury readings. Messrs. C. A. Beach, H. C. Russ and J. Buckley were in charge.

W. Becker's Aniline & Chemical Works, Brooklyn, N. Y.:—A very interesting exhibit showing many articles of various materials that had been colored with their American-made aniline dyes. They also showed their dyes and intermediates in the various stages of the process of production. Messrs. Becker, Miller and Drobegg were in charge.

Bethlehem Foundry & Machine Co., So. Bethlehem, Pa., exhibited several pieces of machinery made of "Tantiron" for manufacture of acids. A fume pipe weighing about 3600 lb. attracted attention. Messrs. W. A. Wilbur, G. J. Lehman and R. E. Wilbur were in charge.

The Bristol Company, Waterbury, Conn.:—Complete line of temperature recording apparatus, pressure and vacuum gauges, and heat regulating instruments, of both indicating and recording types. Special attention was given to their new automatic temperature compensator for the cold ends of pyrometer thermo-couples, and their new continuous flow wet and dry bulb recording thermometer. Mr. H. W. Moss was in charge.

Brown Instrument Co., Philadelphia, Pa., exhibited their stationary and portable electric pyrometers, of indicating and recording types, and also automatic heat-control for furnaces, retorts, etc., and recording thermometers, both of which are new lines with this company. Messrs. Goheen, Andrews and Murray were in charge.

The Buffalo Foundry and Machine Company had the most elaborate and comprehensive exhibit, covering the whole west front of the main floor and occupying 1920 sq. ft. The total weight of the apparatus shown was about 200,000 lb. The principal pieces of apparatus shown were: A Nitrator weighing 24,000 lb. and of 1600-gal. capacity with closed end cooling tubes and water jacketed sides and bottom; a Caustic Pot of 2500-gal. capacity, 10 ft. 4 in. diameter and weighing 26,000 lb.; a Sulphonator, cast-iron jacketed, 700-gal. capacity; an Evaporator, 8 ft. diameter; a Vacuum Drum Dryer in operation reducing Sulphite waste liquor containing 50 per cent moisture to a dry powder (motor driven). This required installing a steam boiler and water and sewerage connection. A Surface Condenser in operation; a Dry Vacuum Pump, two-stage type, motor driven; a Vacuum Shelf Dryer; a Fusion Kettle equipped with stirring device, 600-gal. capacity; a Crystallizing Pan used in manufacturing Ammonium Nitrate, 6 ft. diameter; an Autoclave, 200-gal. capacity with jacket and designed for 1000-lb. working pressure; also another laboratory size Autoclave, gas heated; a Nitric Acid Retort and Condensing System, 9 ft. diameter, 14 ft. high, weighing about 14 tons. An illuminated transparency of their plant and products was also shown. Many of the pieces of apparatus were of a size up to the transportation facilities of the railroad. The entire display was more on a basis of a permanent exhibit such as used in a World's Fair rather than for a six-day exhibit. Mr. H. D. Miles, president of the company, was in attendance all through the week. Mr. E. G. Rippel, sales manager, who arranged the attractive display, was also in constant attendance with a large staff of engineers.

Butterworth-Judson Corporation, New York City, exhibited a line of heavy chemicals, iron ores, and their by-products, and the coal tar products of the American Synthetic Dyes, Inc. Messrs. E. E. Dougherty and M. L. Hamlin were in charge.

Carborundum Co., Niagara Falls, N. Y.:—Of particular interest to chemists was their exhibit of refractory articles such as pyrometer tubes, resistance rods, fire-bricks and muffles. They also displayed a very complete line of abrasives. The booth was in charge of Mr. Roy Lincoln.

Carolina, Clinchfield & Ohio Ry., Johnson City, Tenn., exhibited products of manufactures and natural resources located along their line. Mr. V. V. Kelsey was in charge.

Carrier Engineering Co., New York City, exhibited complete apparatus in operation for cooling about 4000 cu. ft. of air per minute 10 deg. The air was washed and cooled by water spray, but no dampness was noticed in effluent air. The cooling effect was due entirely to evaporation. An automatic humidity regulator on the booth post controlled the humidity of the discharged air by controlling the volume of air delivery. Mr. J. I. Lyle was in charge.

Celluloid Zapon Co., New York City:—Lacquer enamels, lacquers, nitrocellulose and an extensive display of different applications of "Zapon." Included in this booth was an exhibit of the Zapon Leather Cloth Co. Mr. N. E. Daboit was in charge.

The Central Foundry Co., New York City, exhibited its "Universal" cast-iron pipe with machined joint. On account of the tight fit this joint does not need caulking. Mr. R. W. Courou was in charge.

Chemical Catalog Co., New York City, showed a dummy illustrating the nature of its directory of chemical apparatus manufacturers which is now on the press. Mr. F. M. Turner was in charge.

Chemists' Club, New York City:—Booth for the use of visitors.

Chemical Company of America, New York City:—Coal tar intermediates, toluene, xylidine, benzidine sulphate, dimethylaniline and aniline. Messrs. C. Kendall and C. Christ were in charge.

Coatsville Boiler Works, New York City:—Samples of materials used in the construction of their tanks, boilers, etc. Also photographs of installations of their equipment.

E. J. Codd Co., Baltimore, Md., exhibited its chain screen door for various furnaces—metal, chemical, glass, etc. It is claimed that this door is just as effective as a solid door in keeping the heat in and the cold out. Mr. H. H. Wiegand was in charge.

Condensite Co. of America, Bloomfield, N. J.:—A very interesting exhibit showing the various uses for Condensite and Halowax. Condensite is mainly used as an electrical insulator. It has been recently tried as a substitute for the metals in printing plates, and has shown fine results. Halowax is used for electrical condensers on account of its high specific inductive capacity. Both are synthetic products. Mr. Sanford Brown was in charge.

Contact Process Co., Buffalo, N. Y., showed its products, such as sulphuric acid, muriatic acid, nitric acid, oleum, salt cake and nitre cake. The "oleum 50 per cent" attracted much attention on account of its high strength. Mr. E. R. Henderson was in charge.

Corning Glass Works, Corning, N. Y., showed a very complete line of glassware for all fields, such as their "Pyrex" brands of both chemical and oven ware, and lantern glasses, optical glasses, lenses, battery jars, bulbs, tubing and their various light filters. Mr. I. B. Cary was in charge.

Corn Products Refining Co., New York City, showed samples of various corn products. Messrs. T. J. Donnelly and G. M. McNider were in charge.

The J. H. Day Co., Cincinnati, Ohio:—A line of dry powder mixers, mixers for liquid and pasty materials, sifters. Represented by Mr. R. W. Wallace.

De Laval Separator Co., New York City, exhibited several types of centrifugal separators and clarifiers and filters.

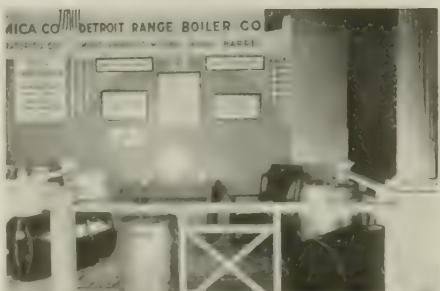
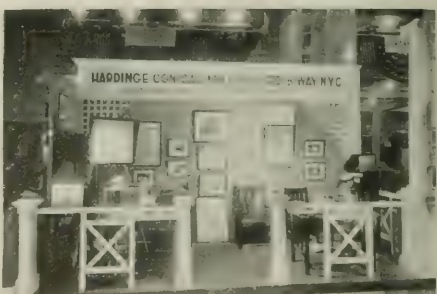
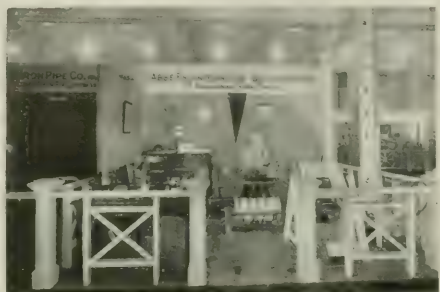
Denver Fire Clay Co., Denver, Col., showed a line of crucibles, muffles, scorifiers and cupels for the clay end of the company. In the machinery class the company exhibited Case disk pulverizer, crusher, cupel machine and laboratory flotation machine, and oil-fired tilting crucible furnace, assay and melting furnaces. Mr. W. W. Case, Jr., was in charge.

Detroit Range Boiler Co., Detroit, Mich.:—"Perfect" metal bilge-barrel with full removable head; also barrels with full draining bung; Detroit drums. Mr. W. B. Goddard in charge.

J. P. Devine Co., Buffalo, N. Y., had a very interesting booth, inasmuch as it exhibited the first vacuum double-drum dryer for American practice. This particular piece of machinery was built especially for the exposition. The company also exhibited one of its 1000-lb.-pressure auto-claves. Messrs. Joseph P. Devine, F. Howard Mason and Nathan Owitz were in charge.

Dorr Company, New York City, exhibited a working model of a three-deck washing classifier, showing its application to fine granular materials. Silica sand and indigo were used in the demonstration. The company also showed models of thickeners or dewaterers, and agitators or mixers. Messrs. H. N. Spicer, Howard Morgan, N. Cunningham, R. Shafer and F. F. Peters were in charge.

The Dow Chemical Co., Midland, Mich.:—Organic chlorine and bromide compounds, synthetic indigo and dye inter-



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mediates. Messrs. A. E. Converse, H. H. Dow, James T. Pardee, W. H. Van Winckel and J. L. Camp in attendance.

Downington Manufacturing Co., East Downington, Pa., displayed a small working model in operation of the Miller patent duplex beater for paper pulp, and also a small beater for laboratory purposes. Showed yellow-pine products of the Empire Chemical Company that had been recovered by the Clope process. Messrs. Guyon Williams, C. L. Ellis and Jacob Edge were in charge.

Driver-Harris Wire Co., Harrison, N. J., had a very attractive booth, part of which was fitted up to resemble a heat-treating furnace in operation. In the "red-hot" interior could be seen one of the company's "Nichrome" carburizing boxes. The company also exhibited wire mesh baskets, trays, woven and cast containers for cyanide baths and heat-treating. Mr. S. M. Tracy was in charge.

E. I. Du Pont, De Nemours & Co., Wilmington, Del., showed samples of their various products, among which were bronze powders, pyroxiline solutions and intermediates. Their various split-leather solutions were shown by samples of rough split leather. An exhibit of Fabricoid, a substitute for leather, was also included, as were also the rubber-coated fabrics of the Fairfield Rubber Co. Mr. R. L. Vilas was in charge.

Duriron Castings Co., New York City, showed a varied line of acid, alkali and rust proof castings, including centrifugal pumps operating with a storage tank, also various standard pipes, fittings, plug cocks and globe valves. Of especial interest were the two types of the Hough nitric acid condenser, one with Duriron tubes and the other with glass tubes. Messrs. J. W. Pitman, F. W. Kolb, J. S. Miller, Jr., and R. F. Schmidt were in charge.

Eimer & Amend, New York City, exhibited a great many of their laboratory supplies, consisting to a large extent of American-made apparatus, among which were the Fleming carbon-combustion apparatus, Emerson carbon-combustion train, Brinell meter, Gramercy constant-pressure blowers, Barnstead water still, Freas constant-temperature electric ovens, Veit electrolytic apparatus, Emerson adiabatic calorimeter, Ziess optical goods, Pyrex and Frye laboratory glassware, Coors porcelain ware and a full line of replaceable unit electric furnaces. Messrs. E. Child and T. M. Sauter were in charge.

Thos. A. Edison, Orange, N. J.:—Benzol, toluol, xylol and numerous other coal tar products. A motor-truck size of his alkaline battery, showing the nickel flake, nickel hydroxide and iron oxide, attracted considerable attention. Mr. W. Mallory was in charge.

Electro Bleaching Gas Co., New York City:—Showed a varied line of fabrics that had been bleached with Liquid Chlorine. Also exhibited some of their chlorinating apparatus, and a full line of alkalies, of the Niagara importance caustic potash, manufactured by the Niagara Alkali Company. Messrs. Thos. W. Pritchard, J. R. Kienle, Chas. S. Sawyer, and J. R. MacMillan were in charge.

The Electro-Chemical Co., Dayton, Ohio:—Passage type electrolytic cell, intermittent type electrolytic cell, finished and Unfinished bleached products of paper and textile mills. Represented by Messrs. J. R. Pfeifer and John Gerstle.

Electrolytic Zinc Co., Inc., New York City:—Samples of electrolytic zinc. Mr. A. W. Hahn was in charge.

Electron Chemical Co., Portland, Maine, exhibited photographs of installations of Allen-Moore electrolytic cells in commercial practice of their design. They hold the patent rights for this cell. Mr. H. I. Allen was in charge.

Elyria Enameled Products Co., Elyria, Ohio, exhibited a large glass-lined nitrating kettle with new design removable jacket. Demonstration of thorough mixing by off-centre and side agitation; showing of new glass-enameled evaporating pan with cast-iron instead of steel base. The durability of this glass-enameled ware was demonstrated by causing a sudden change of about 500° F. in it without any resulting sign of fracture. Represented by Messrs. W. E. Gray, J. O. K. White, R. F. Goecke, E. P. Post, E. H. Hase-rodt and W. E. Gray, Jr.

The Fabra Company, Ltd., New York City:—Mr. W. A. Brassard was on hand to enlighten those who contemplated exporting chemicals to England.

Footo Mineral Co., Philadelphia, Pa.:—Exhibit of unusual ores and minerals including zirconia ore. Refractory bricks, zirconia ware (zirkite), zirconia silicate, zirkite cement, all made from zirconia ore, formed an important part of their display. A stereopticon machine showed pictures of their new American monazite deposit, and a complete line of tungsten ore and tungsten products were also of particular interest. Messrs. H. C. Meyer and Edw. Foster were in charge.

The Foxboro Co., New York City, exhibited a complete line of indicating and recording instruments for tempera-

ture, pressure, speed, time, flow, humidity, and temperature control. Messrs. W. W. Patrick, H. B. Bernard, and C. E. Sullivan were in charge.

Franco-Swiss Colours Co., New York City:—Coal tar colors. Had a demonstration of dyeing to show the fastness, strength and quality of their colors. Mr. W. V. N. Powellson was in charge.

Freeport Sulphur Co., New York City, exhibited sulphur in native and refined states. Mr. S. L. Parsons, Jr., was in charge.

Chas. F. Garrigues Co., New York City, exhibited samples of chemicals used in the manufacture of explosives, and Draper Manufacturing Company's steel barrels. Mr. Alfred Varian, Jr., was in charge.

Geissinger Regulator Co., New York City:—Demonstration of the Geissinger industrial temperature-control system for all classes of heat-control work, such as conveyor type ovens, large flue dampers in superheaters, etc. Mr. H. W. F. Threse was in charge.

General Bakelite Co., New York City, exhibited various products, mostly for use as electrical insulators, made from Bakelite. A new application has been made possible by the advent of a process for coloring Bakelite to harmonize with Circassian walnut, mahogany, etc. One manufacturer is now using it for knobs on dental chairs. Another new application of Bakelite is in impregnating sheets of canvas, which are later pressed together, for the manufacture of noiseless gears and pinions. Mr. H. S. May was in charge.

General Chemical Co., New York City, displayed their own line of heavy chemicals and had space for the following subsidiaries: Baker and Adamson, N. Y. C., standard C. P. acids and salts for laboratory use, and dye intermediates. Benzol Products Co., N. Y. C., aniline salt, nitro benzol oil, and dye intermediates. Ryzon Baking Powder Co., N. Y. C., baking powder. Messrs. J. E. Wilson, Geo. Vardy, and R. W. Mitchell were in charge.

General Electric Co., Schenectady, N. Y., did not attempt to display any equipment but had Mr. W. O. Jones and others on hand to answer any inquiries.

German-American Stoneware Works, New York City, exhibited a very complete line of chemical stoneware, ranging in size from small tower fillings to a 528-gallon storage vessel, including valves, mixing bottles, tourrills, and automatic acid eggs. Of especial interest was a centrifugal pump, and an exhaustor which had been tested up to 4500 r.p.m. Messrs. Percy Kingsbury and B. S. Cameron were in charge.

Glens Falls Machine Co., Glens Falls, N. Y., exhibited their standard 36-inch Tromblee & Paull rotary sulphur burner of which they are the sole manufacturers. Mr. Fred B. Chappell was in charge.

Golden Chest Mine, New York City:—A high grade tungsten ore from the Golden Chest Mine at Murray, Idaho. Mr. Vivian Green was in charge.

Great Western Power Co., San Francisco, Cal.:—Data and photographs relative to the hydro-electric developments and possibilities of electrochemical industries on the Pacific Coast. Mr. J. W. Beckman was in charge.

Emil Greiner Co., New York City, exhibited glassware and miscellaneous laboratory supplies, including different types of apparatus for gasometric determination of which the DuPont nitrometer was of particular interest. Mr. M. F. Kraissl was in charge.

Hardinge-Conical Mill Co., New York City:—Complete working model of the Hardinge Mill with glass arranged so that the inside workings could be seen. This is a continuous feed and discharge grinding machine. Samples of materials ground and unground. An automatic stereopticon showed pictures of various installations. Mr. R. Clark was in charge.

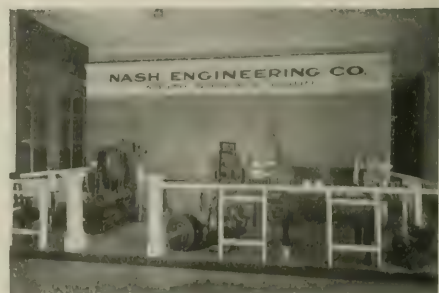
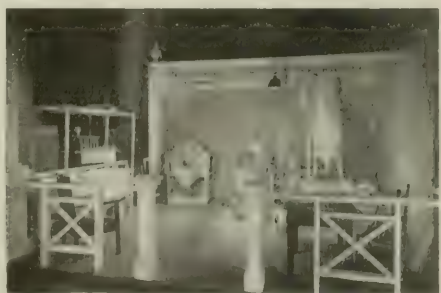
Harrison Bros. & Co., Phila., Pa., exhibited chemicals used in the manufacture of pigments, dyes and paints for fireworks, red danger lights, textiles, linoleums, etc. Mr. P. Garrod was in charge.

S. F. Hayward & Company, New York City, showed a line of safety appliances, including respirators, gas masks, helmets and goggles. Mr. Pratt was in charge.

Frank Hemingway, Inc., New York City, exhibited a line of coal tar derivatives, manufactured and imported. A stenographer was present for the convenience of the visitor and Mr. H. Dixon was on hand to answer any questions proposed.

Herold China & Pottery Co., Golden, Colo., showed a line of Coors chemical and scientific porcelain, of which they are the manufacturers. Mr. C. F. Quaintance was in charge.

Herman A. Holz, New York City, showed samples of the application of Rhotanium as a substitute for platinum; Beighlee pyrometer equipment and portable Brinell meters. Mr. Holz was in charge.



Exhibits at Second National Exposition of Chemical Industries

Hooker Electrochemical Co., New York City, exhibited its electrochemical products.

Huh Electrostatic Separator Co., Boston, Mass.:—Small working model of the Huff separator which uses 12 to 28,000 volts on ore separation, and a small model of the Plumb pneumatic jig for ore separation. These are both dry processes. Mr. H. B. Johnson was in charge.

F. C. Huyck & Sons, Albany, N. Y.:—Samples of their woven woolsen filter cloths and "Kenwood" felts. Messrs. F. J. McGovern, W. A. Yule and D. C. Jordan were in charge.

Industrial Filtration Corporation, New York City, showed a rotary continuous vacuum filter and its removable leaf or cell type vacuum filter. This latter consisted of two tanks with an overhead traveling set of filter plates provided with suction line. This set of plates could be transferred from one tank to the other by washing after forming the cake in the first tank. Messrs. W. H. Harding, Jr., and H. B. Faber were in charge.

International Equipment Co., Boston, Mass.:—Display of laboratory centrifuges for experimental and analytical purposes, for textile industry, and for chemicals. Mr. Arthur Kendrick was in charge.

International Glass Co., Millville, N. J.:—Complete line of glass tubing, chemical apparatus and laboratory glassware, featuring their American-made Insol beakers and flasks. Mr. Paul O. E. Frederick was in charge.

Kieselguhr Co. of America, New York City, demonstrated its well-known torch test on a brick of "Sil-O-Cel." An automatic stereoscopic machine showed detailed illustrations of various installations to which this heat insulating product has been adapted. Another product of Celite that they showed was "Filter-Cel" for use in filtration. Celite is also used in "bulking" products. Messrs. P. A. Boeck, A. H. Krieger and D. S. Collins were in charge.

F. Kleinschmidt & Company, Buffalo, N. Y., had on exhibition one of their small self-cleaning, rotary evaporators. Mr. D. H. Kleinschmidt was in charge.

A. Klipstein & Co., New York City:—Coal tar products; sulphur black, blue and green; sulphurated oils; varnish gums; and tanning material of which their "Oxi-tan" came in for most attention. Mr. E. C. Klipstein was in charge.

H. Koppers Co., Pittsburgh, Pa., showed a model of a by-product coke oven. Also samples of coke made from coals from various States, primary coal-tar derivatives, and various photographs of plants constructed by them. Mr. H. B. Kirkpatrick was in charge.

L. O. Koven & Brother, Jersey City, N. J., exhibited their Kelly filter in conjunction with Dr. Emil E. Lungwitz.

The Laboratory Supply Co., Columbus, Ohio:—Complete line of Ohio Pottery Co.'s "Circle S" chemical porcelain, complete line of "Solno" chemical glassware. "Circle S" filter paper, microscopic slides. Represented by Messrs. Robert Carl Schroth, Jr., C. L. Schroth and C. D. Fraunfelder.

Lead Lined Iron Pipe Co., Wakefield, Mass., exhibited lead lined valves and pipe fittings. A feature of their exhibit was a sample of a sixteen-inch lead lined pipe. Mr. S. H. DuBois was in charge.

Leeds & Northrup Co., Philadelphia, Pa., exhibited a complete line of apparatus for measuring conductivity of electrolytes; electrometric titration apparatus for determination of chromium and vanadium in steel and other alloys; indicating and recording pyrometers; and hydrogen ion apparatus, which is a new line they are exploiting. Mr. C. S. Redding was in charge.

Lehigh Car, Wheel and Axle Works, New York City:—Gray charcoal iron castings, sprocket wheels, car wheels, "Titanite" lining for grinding machinery. Model of the Fuller-Lehigh pulverizer. Space in this booth was also used by the Lehigh Foundry Company, Fullerton, Pa., acid resisting castings; the Lehigh Stoker Co., Fullerton, Pa., and the Fuller Engineering Co., Allentown, Pa., who specialize in the design and construction of grinding plants. Messrs. C. R. Rinehart, L. A. Salade, Bernard Enright, Edward Fromm, and W. A. Stubblefield were in charge.

Life-Saving Devices Co., New York City:—Demonstration of the operating principles of their "Lungmotor." Mr. S. N. Fowler was in charge.

Arthur D. Little, Inc., Boston, Mass.:—Showed interesting blue-prints of some of the industrial plants they have designed. Mr. H. S. Skinner was in charge.

Emil E. Lungwitz, New York City, exhibited the Kelly filter press in conjunction with L. O. Koven & Brother. This was the 450 sq. ft. size filter of which all the features could be examined. Dr. Lungwitz was in charge.

Luzerne Rubber Co., Trenton, N. J., exhibited various articles made in hard rubber to resist chemicals such as pipe and pipe fittings, acid buckets, color boxes, check valve bowls, funnels, etc. Mr. W. L. Royall was in charge.

Madero Brothers, Inc., New York City:—Exporters of chemicals.

Marden, Orth & Hastings, New York City, had their booth very nicely equipped with wall cabinets containing yarns of wool, silk and cotton showing the great variety of colors secured from their wood and aniline dyes. Samples of chemicals, oils, etc., manufactured in their plant were also displayed. Mr. H. G. McKerrrow was in charge.

Merck & Co., New York City, exhibited a shelf of their well-known "Blue Label" reagents, and large jars of hydroquinone (American-made), synthetic carbonic acid, pure benzol, aniline oil and other products. Messrs. G. H. Copeland, O. S. Putnam and R. L. Lauber were in charge.

Metallurgical and Chemical Engineering, New York City, placed its booth at the disposal of visitors and exhibitors with respect to telephones, clerical and stenographic service. Mr. Hays was in charge. Messrs. Muir, Bedell, Munn, Rogers, Cain, Bergen, Crummins, and Soltau were in attendance.

Metals Disintegrating Co., New York City, showed samples of their powdered magnesium, lead, tin, zinc, and aluminium. Mr. A. W. Hahn was in charge.

Mine & Smelter Supply Co., New York City:—Lindsay oil furnace, Colorado clay products, Samson laboratory crusher, McCool pulverizer, Redwood pipe and, of particular interest, Heusser analytical and assay balances, with patent pan extractor and multiple weight attachment. Mr. J. S. Shedden was in charge.

Mississippi River Power Co., Keokuk, Iowa:—Views of plant and equipment, maps of power zone. Represented by Mr. Norman T. Wilcox.

Monsanto Chemical Co., St. Louis, Mo., displayed the following chemicals: Acetanilid, acetphenetidin, caffeine, chloral hydrate, conmarin, glycerophosphates, phenol (U. S. P.), phenolphthalein, saccharin and vanillin. Mr. B. M. Covault was in charge.

J. L. Mott Iron Works, New York City, showed cast-iron, steam-jacketed and porcelain-lined mixers and kettles. Mr. R. H. Horne was in charge.

Multi-Metal Separating Screen Co., New York City:—Screens in bronze, brass, copper, nickel and Monel metal for filtering and sifting. Also a line of safety devices, including hoods, masks, respirators and goggles. Messrs. F. Stern and S. Stern were in charge.

Nash Engineering Co., South Norwalk, Conn., exhibited a hydro-turbine wet vacuum pump in actual operation, with means for obtaining the horsepower of the pump by measuring the reaction of the motor frame, which was hung on ball bearings, and the quantity of air handled by orifice and mercury gage. An unassembled standard hydro-turbine showed the interior details. The company's line of Xyloform products in the forms of paint, varnish, egg preservatives and grease-proofing compound for paper were also shown. Mr. I. S. Jennings was in charge.

National Aniline & Chemical Co., New York City, exhibited the Schoellkopf aniline dyes. Dr. Watkins was in charge.

National Gum & Mica Co., New York City:—Dye-wood extracts, carbon bisulphide and Mikah cold glues. Dr. Jerome Alexander was in charge.

City of Newark, N. J.:—Maps and photographs of Port Newark Terminal. Mr. J. C. Hallock was in charge.

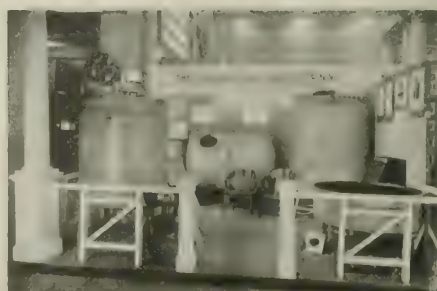
Newport Chemical Works, Inc., New York City, exhibited "Newport" rosin. The quality and transparency of this product were well shown by placing a high-powered light behind a layer of it. Mr. J. R. M. Klotz was in charge. Messrs. Cranz, Turner, Burd and Mackie were present.

Norton Company, Worcester, Mass.:—Exhibit of "Alundum" crucibles, tubes, etc., for carbon determination and various other refractory apparatus of Alundum and Crystolon. A demonstration was made of the porosity of Alundum by constantly passing a liquid through a crucible of this material. The columns at the corners of the booth were coated with Crystolon. Mr. P. G. Savage was in charge.

The Palo Company, New York City:—Extensive line of chemical and metallurgical apparatus—Irite pyrometers, gas-testing apparatus, spectrometers, etc. Dr. F. Rohde and Messrs. B. A. Foley and Schaefer were in charge.

Patterson-Allen Engineering Co., New York City, exhibited its lead-lined, alloyed and plain "Everlasting" valve in sizes from 1/4 in. to 24 in. Mr. C. Davey was in charge.

Pennsylvania Salt Mfr. Co., Philadelphia, Pa., showed quite an extensive line of products in which its products are used, also samples of its acids, salts and other chemicals. Of particular interest to the visitors were the many shapes in which some of the salts were shown—crystal lettering, crystal basket, solid barrel of aluminium sulphate and a chessboard made of Greenland kryolite. Mr. C. A. Hall was in charge.



Exhibits at Second National Exposition of Chemical Industries

The Pfauder Company, Rochester, N. Y., had an exhibit showing various glass-lined steel tanks and other apparatus, including a one-piece tank, a steam-jacketed mixing tank for nitration purposes; also rubber and lead lined tanks. Mr. F. L. Craadock was in charge.

Pittsburgh Testing Laboratory, Pittsburgh, Pa., exhibited some of its chemical products and reports to show the scope of what it does.

Precision Instrument Co., Detroit, Mich.:—One 3-in-1 gage registering forced draft, combustion chamber vacuum and last-pass vacuum, showing differentials through the boiler and through fuel bed, differential pressure gage for low reading, line of CO₂ recorders, orsats and recording gages. Mr. A. T. Baldwin in charge.

Prest-o-Lite Co., Inc., Indianapolis, Ind., exhibited bunsen burners, lead-burning equipment, soldering, brazing, welding and cutting torches, and various sizes of its storage battery. Mr. M. J. Ryan in charge.

Process Engineers, Ltd., Montreal, Que.:—Rosin sizing process for paper mills. Messrs. J. A. De Cew, H. A. Radford and R. B. Bert were in charge.

The Product Sales Co., Baltimore, Md., exhibited kaolin, feldspar and quartz.

Pyroelectric Instrument Co., Trenton, N. J., featured the "Pyrovolt" pyrometer. Also showed electric furnaces, adapter boxes and resistance cubes. Dr. E. F. Northrup and Messrs. Dudley Wilcox and H. F. Porter were in charge.

Raritan Copper Works, Perth Amboy, N. J., exhibited ingots and wire bars of "Anaconda" electrolytic copper and "N. E. C." electrolytic zinc; also showed nickel sulphate and copper sulphate recovered; selenium in various forms, tellurium, and gold and silver bars. Mr. S. Skowronski was in charge.

Raymond Bros. Impact Pulverizer Co., Chicago, Ill.:—Samples of over 100 different air-floated products reduced by Raymond Mills in chemical and industrial institutions; also detailed illustrations of principal machines and drawings of installations. Messrs. C. M. Lauretzen, William B. Seneman, W. M. Cook and Samuel B. Kanowitz in attendance.

Research Corporation, New York City, showed a small working model of the Cottrell electrical precipitation process for removing dust from gases. Frequent demonstrations were given and attracted a great deal of attention. The voltage used was about 40,000, whereas in actual practice up to 100,000 is used. Messrs. Linn Bradley, A. F. Meston, P. E. Landolt and H. D. Egbert were in charge.

Richmond Waterproof Products Co., New York City, exhibited waterproof cements for cementing parquets and linoleums to concrete. Messrs. George T. Simonson, J. J. Wilson and A. Falstra were in charge.

Roessler & Hasslacher Chemical Co., New York City, exhibited metal cyanides and "Trisalts" for electroplating, and other chemicals.

Ruggles Coles Engineering Co., New York City, exhibited a working model of their class A double shell direct heat type dryer. Mr. F. E. Fitch was in charge.

Schaeffer & Budenberg Mfg. Co., Brooklyn, N. Y., exhibited indicating and recording gages and thermometers of their Columbia and Crescent brands; also steam calorimeters and indicating and recording tachometers; chemical thermometers; mercury pressure and vacuum gages; mercurial barometers and gage testers. Their recording apparatus was demonstrated by a complete testing outfit.

Schaum & Uhlinger, Inc., Philadelphia, Pa., displayed photographs and blue-prints of their various types of centrifugals. Messrs. C. W. Schaum and Leslie Griscom were in charge.

Schulte & Koerting Company, Philadelphia, Pa., had a complete testing installation of an atomizing spray nozzle for use in acid towers. They also exhibited their Bihn-Jones automatic apparatus for lifting liquids; acid-resisting and reducing valves; spray nozzles; oil firing apparatus and oil and water heaters. Dr. C. Kimberley was in charge.

Scientific Materials Co., Pittsburgh, Pa., had an extensive display of general laboratory supplies, in which the "Scimatco" brands played an important part. Messrs. L. W. Hoshour, T. W. Clark, G. H. A. Binz and J. Seavy were in charge.

Ernest Scott & Co., Fall River, Mass., showed photographs and blue prints of plants and machinery designed and installed by them, especially vacuum and distillation plants. Also samples of apparatus for recovering trade wastes, and some of the products. Messrs. H. Austin and A. B. Kennedy were in charge.

Seydel Manufacturing Co., Jersey City, N. J.:—Aniline oils and derivatives; sizings for cottons, woollens, etc.; olive oil soaps.

Sharples Specialty Co., West Chester, Pa., showed their smallest and largest types of super-centrifuges. Principal

interest in these machines is their high speeds, the small one traveling at 40,000 r.p.m. and the large one at 18,000 r.p.m. They are hung from balls and are free at the bottom so that they find their own centers. Samples of some of the Sharples processes, among which were wool fat, glue, cider, crude sugar, benzene, and varnish, showed the machine's wide application.

T. Shriver & Company, Harrison, N. J., showed for the first time a new model of filter press possessing rotary features which perform all of the duties without the need of taking the machine apart. A running test of calcium carbonate was made on this machine during the show. They also exhibited one of their standard plate filters and a filter type oxy-hydrogen generator. Mr. H. D. Atkins was in charge.

Sidio Manufacturing of America, New York City, exhibited a very complete line of American-made fused silica ware for chemical apparatus. Mr. Otto Trautman and S. Herlinger were in charge.

The Solvay Process Co., Syracuse, N. Y., exhibited the various alkalis that they manufacture. In conjunction with this exhibit was that of the Semet-Solvay Co., which showed photographs and blue-prints of by-product coke oven plants which they designed or are operating.

Sowers Manufacturing Co., Buffalo, N. Y., showed Dopp seamless, steam jacketed kettles, mixers and vacuum pans. Messrs. W. Bowman, P. B. Cox and H. H. Blake were in charge.

E. R. Squibb & Sons, New York City, exhibited a general line of reagents. Messrs. Schad & Cary in charge.

Stamford Mfg. Co., New York City, showed furs, silks, woollens, cottons, and leathers dyed with their vegetable dyes. The logwood produces the blacks and blues, the fustic produces the yellows and browns, the hypernic produces the reds, and these are further mixed to produce other shades. Mr. H. G. Stanley was in charge.

Standard Aniline Products, Inc., New York City, exhibited coal tar dyes, intermediates, resins, and other chemicals. Dr. Wallach was in charge.

Stevens-Aylsworth Co., New York City, demonstrated the proper and improper methods of tank agitation. Exhibited sections of their tin, copper, lead, gold and silver-lined apparatus. Messrs. W. N. Stevens, R. G. Stevens and R. P. Aylsworth were in charge.

Stone & Webster Engineering Corp., Boston, Mass., showed several photographs showing industrial and power plants that were designed and constructed by this company. Mr. R. W. Gilbert in charge.

The Stuart & Peterson Co., Burlington, N. J.:—Porcelain lined, steam jacketed kettles, stills, autoclaves, and storage tanks. Messrs. J. J. Kearns and Frank Hearn were in charge.

Sturtevant Mill Co., Boston, Mass., exhibited their crushing, grinding and screening machinery, ring roll mill, "Newaygo" separator, and roll jaw crusher.

Sweetland Filter Press Co., Brooklyn, N. Y.:—The demonstration of this filter press attracted considerable attention as a complete small working filter was in operation. The metallic filter cloth used in conjunction with the press was also a source of much interest. A new trunnion type of filter press for laboratory use was also exhibited. Mr. A. W. Wright was in charge.

Swenson Evaporator Co., Chicago, Ill.:—Working model of a standard Swenson horizontal tube double effect evaporator and samples of some of the materials handled in Swenson evaporators. Messrs. F. M. De Beers, P. B. Sadler, P. H. Appell and H. Perlstein in charge.

Swiss Colours Co., Inc., New York City, displayed cottons, woollens, silks, furs, leathers, felts and feathers which had been dyed with the products of the American Aniline Products Co. for which they are the selling agents. Mr. B. R. Armour was in charge.

Takamine Laboratory, Inc., New York City, exhibit Polyzine, a diastatic extract, and Newmalt, a substitute for malt extract. Both are American-made. Messrs. Eben Takamine and Jokichi Takamine were in charge.

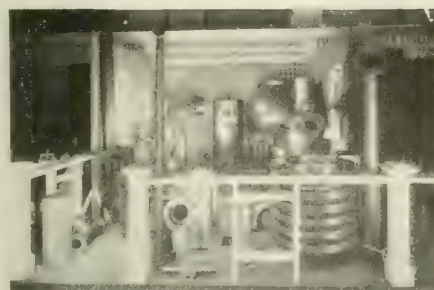
Taylor Instrument Companies, New York City, exhibited "Tycor" indicating and recording thermometers, pyrometers, oil testing instruments, barometers, Hygrodek hydrometers, etc. Messrs. H. W. Turner, James Ely, D. C. Day, Jr., N. H. Nelson and Ray Taylor were in charge.

Technical Association of Paper and Pulp Industries maintained a booth for registration of its members during the exposition.

Tennessee Coal, Iron & Railroad Co., Birmingham, Ala., exhibited products of manufactories and samples of the natural resources located along its line, mining camp model and several pictures showing manufactories and the work being carried on by this company in the Birmingham district.



Exhibits at Second National Exposition of Chemical Industries



Exhibits at Second National Exposition of Chemical Industries

Tennessee Power Co., Chattanooga, Tenn.—Stereoscopic views of company's hydroelectric power houses, transmission lines and general equipment. Also views of chemical industries in the power zone. Represented by Messrs. E. A. Hitchcock and C. F. Long.

The Thermal Syndicate, Ltd., New York City—Complete line of "Vitresoil" laboratory ware and collection of pieces used in various chemical apparatus. Particular interest was noted of a Vitresoil pipe of 15-in. bore and 30 in. long, and condenser pipe of 4-in. bore and 8 ft. 6 in. long. These are the largest pieces ever produced by the electrical fusion of silica. Great interest was shown in resistance of Vitresoil to temperature changes, as illustrated by taking crucibles out of electric furnace at 1000 deg. and plunging them into cold water without breakage occurring. Mr. A. E. Marshall was in charge.

Thwing Instrument Co., Philadelphia, Pa.—Pyrometers, high-resistance multiple-recording pyrometers, also Duriron and carbondurum protecting tubes for thermo-couples. A feature of the company's exhibit was a new type of radiation pyrometer. The exhibit was in charge of Dr. Thwing and Mr. H. K. Walton.

Toch Brothers, New York City, exhibited cement colors, integral waterproofing compound, barium products and chemical dryers. Also had on display finished surfaces and hollow tile showing the quality of their waterproofing paint. Pictures showing many large buildings on which their paints are used were of interest. Messrs. E. A. Marx, F. A. Milligan and S. T. Marcus were in charge.

Tolhurst Machine Works, Troy, N. Y., exhibited each of the following types of centrifugals: Suspended, self-balancing, acid, solid curve and laboratory. They were represented by Messrs. Cady, Gage, Tolhurst, Bryson and Dutton.

Uehling Instrument Co., New York City, displayed a line of fuel economy apparatus, such as Pehling waste meters and carbon-dioxide automatic recording apparatus, draft gages, absolute pressure indicators, draft recorders and pressure recorders. Messrs. F. F. Uehling and S. W. Smith were in charge.

United Cast Iron Pipe & Foundry Co., Burlington, N. J.—Gray iron castings of unusual shapes and sizes. Also photographs showing various castings in use in industrial plants throughout the country.

United Gas Improvement Co., Philadelphia, Pa., exhibited by-products of coal-gas and water-gas distillation, including intermediates, light refined products, road compounds and pitches. Mr. W. H. Fulwider was in charge.

United Lead Co., New York City—Lined and covered pipes in lead, tin, brass and copper; Kemetaline. The company also had on exhibit a piece of lead pipe 2000 years old from Rome. This was well preserved and attracted considerable attention. Messrs. L. B. Gallison, O. M. Hoveman, D. F. Miller and C. B. Holden were in charge.

Union Sulphur Co., New York City—Refined sulphur. Mr. W. N. Wilkinson was in charge.

U. S. Bureau of Census, Washington, D. C.—Several of its publications and charts showing locations of chemical plants and relative information.

U. S. Bureau of Foreign and Domestic Commerce, Washington, D. C., showed several of its publications and some charts.

U. S. Bureau of Mines, Washington, D. C., showed what the bureau was doing to conserve life in mining operations. Of particular interest was a crew of five dummies, each fully equipped with different types of the latest devices used in rescue work. The development of the extraction of radium from pitchblende and carnotite, of the Georgia clays for white tile and ware, and of the evolution of coal attracted further interest. Mr. M. F. Leopold was in charge.

U. S. Bureau of Standards, Washington, D. C., had a large exhibit showing all of its publications and the apparatus used in its work. This included gas calorimeters and meters, pyrometers, thermometers, hydrometers, standard weights, chemical apparatus and much other material. Of especial interest was a new apparatus for finding the density of a gas by determining its specific gravity, which is found by a method of weighing unequal volumes at different pressures. This apparatus is not yet on the market. Messrs. A. N. Finn, J. D. Edwards and William Blum were in charge.

United States Smelting Co., New York City—Specimens of products from all of its subsidiary companies, including different brands of copper, lead, spelter, selenium, gold, silver, platinum, palladium, crushed slag, hydrofluoric acid and miscellaneous ores, and an exhibit showing the different stages in the process from ore to refined copper. A small electrolytic cell in operation refining copper proved interesting to the visitors. Messrs. Sidney Rolle and W. C. Smith were in charge.

Universal Fibre Co., Trenton, N. J., exhibited fiber kegs and powder cans.

Valley Iron Works, Appleton, Wis., exhibited two 250-lb. capacity Vesuvius oxidizing sulphur burners, one of which was dismantled for interior inspection. Mr. R. W. Fannon in charge.

Weiller Manufacturing Company, New Brunswick, N. J., exhibited samples of intermediates, nigrosines and colors, and demonstrated by a full-sized installation the manufacture of paranitraniline. Dr. P. Weiller and Messrs. J. J. White and E. Graf were in charge.

Werner & Pfeiderer Co., Saginaw, Mich.—Vacuum kneading and mixing machinery, rubber compounding and masticating machinery, laboratory mixing machines, rapid dissolvers. Messrs. Emil Staehle, C. Pletscher, A. J. Vollrath, S. D. Gridley and E. Schiller in attendance.

Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.—Thury regulating equipment for electrode control (electric furnace equipment), recording instruments, etc. Ventura fan, automatic control panel, motors, float switch, rheostats, special impregnated motor coils, Bakelite, Micarta products. Messrs. O'Neill, Loomis, Lupinski, Ward, Carrier, Gibson, White, Carpenter, Goldsborough, Gerry, Hegarty and W. H. Easton in attendance.

Whitall-Tatum Co., Millville, N. J., exhibited its "Nonsol" glass in beakers and flasks. Reagent bottles and gray and white filter paper. Messrs. W. W. Figgis, E. T. McCane and G. E. Barton were in charge.

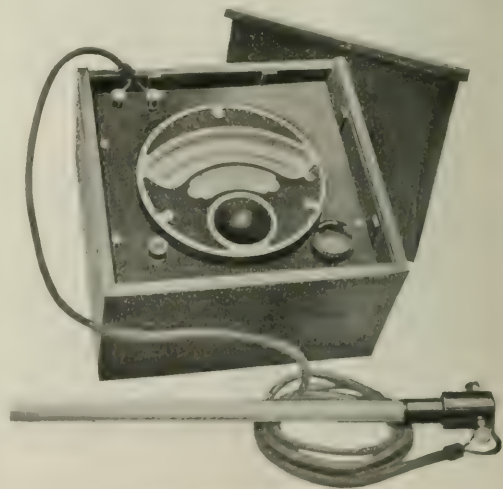
Williamsburg Chemical Co., Inc., Brooklyn, N. Y., showed samples of its monochlor benzol, dinitrochlor benzol, dinitrophenol and sulphur black paste and powder. Also exhibited Hydronol of the United Dyestuff & Photochemical Co., Inc., of Brooklyn, which is similar to the German Amidol. Mr. A. H. Cohen was in charge.

Zaremba Co., Buffalo, N. Y., showed interesting photographs of its evaporating apparatus of various designs and sizes. The company had a 180-sq.-ft. single-effect evaporator on display. Mr. Edward Zaremba was in charge.

An Industrial Potentiometer Temperature Indicator

A new indicator operating on the potentiometer principle and designed for use with any thermocouple has recently been placed on the market by the Pyroelectric Instrument Company, of 148 East State Street, Trenton, N. J., a new company which was incorporated in July. Dr. E. F. Northrup of Princeton University is president and technical adviser, Dudley Willcox is treasurer and H. F. Porter, secretary of the new company.

The new instrument, which was on exhibit at the Chemical Exposition is called the pyrovolter. It com-



GENERAL VIEW OF PYROVOLTER

bins the characteristics of the voltmeter, with the accuracy of the potentiometer, and was designed with the purpose of making the readings of temperature independent of the resistance of the thermocouple circuit, which resistance is apt to vary on account of corrosion, temperature conditions, etc.

The pyrovolt, as such, is not the complete measuring outfit but it is the indicator which enables one to read the voltage developed by a thermocouple of any type whatever, whether made of base metals giving a high electromotive force or of noble metals giving a small electromotive force. To adapt the pyrovolt to thermocouples of different combinations of metals and to read to different temperature-elevations, it is only necessary for the maker to choose particular values of certain resistances and to lay off the scale of the instrument for the temperature range which is desired. The deflection instrument employed is exactly the same for all types of thermocouples and for all temperature-ranges and consists of a millivoltmeter of standard make having the strong spring control commonly given to these instruments. The additional features, which permit the electromotive force of a thermocouple to be read independently of the resistance of the thermocouple circuit, consist of a small dry cell, a small rheostat and a switch operated by a push button. These parts, all being small, are located inside the wooden case in which the instrument is mounted. The push button and the handle of the rheostat are outside the case and occupy two front corners. The two ends of the thermocouple are attached to two binding posts located in another corner of the case.

The small dry cell supplies the energy which deflects the instrument, the thermocouple itself not being called upon to furnish any current for the deflection. The rheostat, operated by the handle outside the case, will move the pointer over the scale of the instrument when the handle is turned. By turning the handle until the pointer stands at the beginning of the scale of the instrument and then pushing the button in the left front corner of the instrument the pointer at once deflects to a point on the scale which indicates the true temperature of the fire end of the thermocouple. Anyone can easily prove that this indication is quite independent of the resistance of the thermocouple circuit by connecting in series with the thermocouple a rheostat and adding with this any resistance to the thermocouple circuit from 0 to 50 ohms or more and observing that the temperature indicated is unchanged by this procedure.

As the indications of the pyrovolt do not depend upon the resistance of the thermocouple circuit, it is not necessary to make the thermocouple wires heavy and of large cross-section, as is commonly done for the purpose of keeping the resistance of the thermocouple very low. Thus wires of small diameter may be used and it is entirely practicable to make the thermocouple wires long enough to reach from the fire end to the binding post of the pyrovolt, even when this is 10 or 15 ft. from the fire end. When the thermocouple wires end in the binding posts of the pyrovolt the cold junction of the thermocouple will have the temperature of the instrument and not some much higher and unknown temperature, as when the thermocouple is short and joined by copper leads to the deflection instrument. The pyrovolt is calibrated to read the temperature very correctly when its temperature is 25 deg. C. (77 deg. Fahr.). If when using the instrument the temperature of this, and consequently of the cold junction, is different from 25 deg. C. this fact may be indicated by a small mercury thermometer which is located at one corner of the case of the instrument. The scale of this thermometer is so laid off that its reading indicates the

number of degrees which must be added to or subtracted from the reading of the pyrovolt to give a perfectly correct measurement of the temperature. Thus, if the temperature of the instrument and cold junction is 25 deg. C. the mercury thermometer will read at zero on its scale and there is nothing to add or subtract from the reading. If the temperature of the instrument is higher than 25 deg. C. the mercury thermometer will read some number, as +3 or +4, which number when added to the reading of the pyrovolt gives the true temperature of the fire end. If the instrument and cold junction is below 25 deg. C. the mercury thermometer will read some negative number.

The temperature of the fire end will then be correctly given by subtracting this number from the pyrovolt reading. As at no time this correction will be large, perhaps in an extreme case as much as 10 deg., this mercury thermometer is not added in general for correcting the reading except as an extra feature. When supplied, the indications of temperature are just as accurate as it is possible to read the position of the pointer on the scale of the instrument.

A New Recording Thermometer

The Brown Instrument Company of Philadelphia is placing on the market a new type of recording thermometer for temperatures to 800 deg. Fahr. (425 deg. C.) which embraces a number of original features.

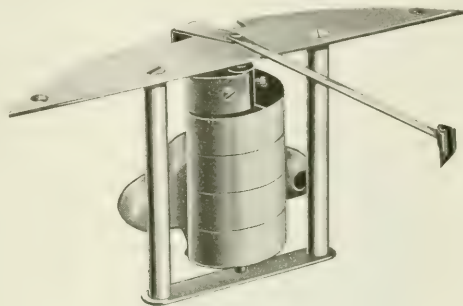


FIG. 1—HELICAL SPRING

This instrument operates on the principle of the expansion of gas with change in temperature. A bulb of copper containing nitrogen gas under pressure is connected to a recording instrument by a small copper tube protected by flexible steel tubing. The recording instrument has a helical spring somewhat similar to that used in pressure gages, and the expansion of the gas in the bulb exerts pressure which is conveyed by the capillary tube to the helix, which expands proportionately.

This helix is directly connected to a recording arm which marks on the record chart.

This type of instrument can be furnished with tubing as long as 100 ft. if required, so that the recording gage can be placed as much as 100 ft. distant from the point where the temperature is measured. This permits of its application in numerous processes where it is desirable to keep a constant record of the temperature on a chart.

Some of the improved features in this new type of instrument follows:

The Seth Thomas clock which revolves the chart is mounted directly on the front plate on which the chart

revolves, which insures alignment of the clock and chart plate.

The clips which hold the chart in position are mounted on the door so that when the door is swung



FIG. 2—RECORDING THERMOMETER

aside these clips are automatically swung away from the chart, permitting its easy replacement without interference.

A device is furnished which raises the chart pen from off the chart automatically when the door is opened, and frees the pen automatically when the door is closed.



FIG. 3—INDICATING THERMOMETER

This instrument is made also in indicating form where desired to indicate the temperature on a dial instead of recording it on a chart.

It is furnished with a number of different types of bulbs, either with threaded connection for insertion in mains and pipes, or with lead coating to withstand chemicals and acids.

Personal

Mr. Merrill G. Baker, assistant sales manager of the American Vanadium Co., Pittsburgh, Pa., has returned from a business trip to Russia.

Officers of the Society for the Promotion of Engineering Education elected at the annual meeting are: President, G. R. Chatburn, University of Nebraska; first vice-president, Hollis Godfrey, Drexel Institute; second vice-president, W. M. Thornton, University of Virginia; secretary, F. L. Bishop, University of Pittsburgh; treasurer, W. O. Wiley, New York, N. Y.; members of the council to serve for three years, E. J. McCaustland, University of Missouri; F. G. Higbee, State University of Iowa; R. W. Gay, Mississippi College; T. E. French, the Ohio State University; A. H. Blanchard, Columbia University; A. A. Potter, Kansas State Agricultural College; Wm. H. Browne, Jr., North Carolina College.

Mr. A. J. Fasbinder, formerly construction engineer at Tampico, Mexico, is now connected with the Carnegie Steel Co., Homestead, Pa., as designing engineer.

Mr. C. E. Georgi, secretary of the Schaeffer & Budenberg Mfg. Co., Brooklyn, N. Y., has been appointed western manager of the company, and is now permanently located at the Chicago office, 427 South Dearborn Street. This appointment was the result of the unexpected and untimely death of the former western manager, Mr. William H. Shenton. Mr. Georgi was formerly New England manager.

Mr. Lyon Smith has resigned as metallurgist for the Snyder Electric Furnace Co. of Chicago, to become assistant superintendent of the River Smelting & Refining Co., Florence, Cal.

Mr. W. H. Staver has removed his office from Lynchburg, Va., to Washington, D. C. He has recently been in Colorado examining property for Boston capitalists.

Notes

The Hydrol Company, Niagara Falls, N. Y., is building a factory for the treatment of oils with hydrogen and the manufacture of artificial paraffine, and is also contemplating the manufacture of dyes from coke by-products to be sent from Pittsburgh.

Duplex Steel Process.—The American Steel & Wire Company has started the manufacture of steel by the Duplex process at its Donora, Pa., plant. A 1300-ton metal mixer was built and installed in the plant by the Pennsylvania Engineering Works, New Castle, Pa., also two 25-ton Bessemer converters, a four-hole soaking pit and there are also eleven 60-ton open-hearth and two 60-ton acid furnaces. The introduction of the duplex process is expected to increase the output of the steel works from 20 to 25 per cent.

The Standard Varnish Works has moved its general offices to the West Street Building, 90 West Street, New York.

Department of Agriculture to Study Dyestuffs.—Co-operation with the manufactures of dyestuffs will be undertaken by the Department of Agriculture under the \$50,000 appropriation contained in the new agricultural appropriation law. The Bureau of Chemistry of the Agricultural Department will be in charge of the study of dyestuffs manufacture, and is already in communication with manufacturers of dyes and large users of colors. It is a new departure for the Government and its development will be watched with interest. Work will at present be carried on in the laboratories of the Bureau but it is hoped to establish a separate laboratory for dyestuff investigation.

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The Steel Market Takes New Life

A new chapter in the history of the steel market has been commenced. Early this year the common view was one of doubt whether full activity at the steel mills would continue throughout the year. The rapid advances in steel prices that occurred in January, February and March, equal to those that had already occurred during the calendar year 1915, seemed to suggest not only a merry life but a short one for the "steel boom." When the buying of steel decreased steadily during the next three months the view seemed to be confirmed that there could be no long period of full mill activity without a general readjustment in prices. Once the heaviest buying had ceased and prices had practically stopped advancing, the testimony of all precedents was that the market movement was over and a fresh start would have to be made.

Now the unprecedented is occurring. The railroads, which had withdrawn completely from the market, have entered it again, although confronted by higher prices than when they withdrew. Freight car buying since Sept. 1 has been at a rate that by the precedents must be considered a good one. Rails are being bought for delivery early in 1918, the earliest delivery obtainable. Other consumers of steel, such as agricultural implement makers, find that the public will buy much more of their goods, at the high prices they must ask, than they had expected. The new information is that the public will pay more for steel than was judged according to the precedents. That is simply because all conditions have changed.

The steel mills are as much crowded with work as they were four months or six months ago and steel prices are advancing much more clearly and sharply than at any time since last March. It can be seen that it is a new chapter in the history of the steel market. How long the chapter will be time must develop.

Wilmington Decision in Miami Flotation Suit

The voluminous record of flotation litigation was enriched on Sept. 29 when Hon. Edward G. Bradford, judge of the U. S. District Court for the District of Delaware, filed his opinion in the case of Minerals Separation, Ltd. vs. Miami Copper Co. Miami Copper was sued for infringement of three patents 835,120; 962,678; 1,099,699. The essential basis of Judge Bradford's decision is that the reduction of oil to less than 1 per cent is patentable. He sustains and declares infringement of claims 1 and 12 of the patent 835,120 and all claims of 962,678. He declares invalid claim 9 of patent 835,120 and all claims of 1,099,699. While technically a "mixed" decision, it is decidedly in favor of Minerals

Separation. In view of the wide interest in the suit, we publish Judge Bradford's decision practically in full elsewhere in this issue.

Judge Bradford's decision is in line with the former decision of the lower Court of Butte, Mont., in the other flotation suit now pending—that of Minerals Separation, Ltd., vs. James M. Hyde, relating to the practice at Butte and Superior. This decision of the lower court at Butte was, however, reversed by the U. S. Circuit Court of Appeals for the ninth circuit sitting at San Francisco, in a decision handed down on May 4, 1914. In the latter decision the Court found the process "fully described in more than one of the patents of the prior art, with the single exception of the reduced quantity of oil." On the latter score the Court held that to make such a claim valid would be "to take from others the right to use oil economically," and that "to sustain the appellee's (Minerals Separation) patent would be to give the owners thereof a monopoly of that which others had discovered." Quoting from another decision the Court then said: "A change in form, proportions or degree, doing substantially the same thing in the same way by substantially the same means, with better results, is not such invention as will sustain a patent."

Thus we have now two decisions, diametrically opposite with respect to the main point (the patentability of less than 1 per cent of oil), one from the District Court of Delaware, the other from the Circuit Court of Appeals for the ninth circuit. The latter decision is now awaiting hearing before the United States Supreme Court. It may be expected that the Miami case will be taken up at the same time by the Supreme Court. As far as we know, there is nothing that would make such procedure impossible, while there is a great deal that would make such procedure highly desirable. It is sincerely to be hoped that it be done, since for the future development of flotation in this country nothing is more important than a speedy final decision on the legal status.

Two remarks of a general nature may be added. First, while modern engineering developments move with Overland Limited speed, the execution of patent laws moves with the speed of the stage coach of our forefathers; yet for efficiency's sake both should move in synchronism. During the time from the end of the hearings to the filing of Judge Bradford's opinion, not only has the experimentation with and the actual application of the process assumed tremendous proportions, but there has also been published in technical literature the fullest discussion, largely from the laboratories of our technical schools, of the underlying principles of flotation. In none of these papers, so far as we have observed, has the relative effectiveness of small as compared with larger quantities of oil been brought out. Have all the experimenters and theorists overlooked this point which now appears all-important in law?

Secondly, different people may agree in very different degree with Judge Bradford's very liberal interpretation of patent law in the text of his Miami opinion. Yet one remark in the opinion will appear to everyone to represent an ideal goal to strive at. In the discussion

of the second patent in suit, the judge finds novelty and patentability in the invention, but adds a note which we commend to the consideration of more than one million patentees in this country: "Even were the grounds on which the validity of the patent can be sustained less clear, it should have the benefit of the *presumption of validity, arising from the grant of letters.*"

If added evidence were needed to show the frightful weakness of our patent system, the whole litigation on flotation should have colossal weight. Would that we could rely with greater certainty on "the presumption of validity arising from the grant of letters."

Coal Reserves and Iron Production

It is well recognized that not the least of the material things for which the present European war is being waged is the possession of very important coal and iron ore deposits near the boundary line between France and Germany. The industrial development of nations has been regulated in very considerable degree by their command of iron and coal. As long ago as in 1866 the English government appointed a Royal Coal Commission to consider the coal reserves of the British Isles, for it was already recognized that the command of coal was a very important factor. In the future history of nations the ability to develop mechanical energy will be an important factor. It may be of interest to show the distribution of the world's coal reserves. We convert into percentages the tonnages given in "The Coal Resources of the World," published in 1913 by Morang & Company, Limited, Toronto, the total tonnage stated being about 74×10^9 :

	Per Cent
Oceania	2
Asia	17
Africa	1
America	69
Europe	11
The World	100

The distribution of pig iron production is quite different. The present capacity is approximately $44\frac{1}{2}$ per cent for the United States, $1\frac{1}{2}$ per cent for Canada, $53\frac{1}{2}$ per cent for Europe, and $\frac{1}{2}$ per cent for the rest of the world, chiefly India, China and Japan.

In the earliest days of iron making, in the United States as well, still earlier in other parts of the world, iron was made where the ore was found, because there was wood everywhere. When mineral fuel came to be used the blast furnace was subject to two attractive forces instead of one. In some happy instances, as in the case of the Birmingham district in Alabama the coal, ore and limestone are all close together. Where a haul is necessary it is almost invariably of the ore rather than of the coal. While the manufacture of pig iron requires less weight of coal than of ore, the conversion of pig iron into useful articles requires much coal in addition.

At the present rate of coal production the known reserves would last the world about 6000 years but if the world's consumption were as great per capita as that

of the United States only 900 years would be required for exhaustion. The people of the United States have been progressing much more rapidly in an industrial way than the people of the world as a whole, this being a result, or a cause, of our large coal production.

It is quite inconceivable, of course, that the world should continue to use coal for the production of energy until the known supplies, let alone others that will doubtless be discovered, even the Antarctic regions presenting possibilities, are exhausted. We have made an infinitesimal beginning at utilizing the solar energy by harnessing some of the water power, we have wave motors, at least for exhibition purposes, and we have unlocked the atom to the extent of using some of its power for medicinal purposes. Can it be long, relative to the possible life of the coal deposits, until we secure more of the energy we need from the atom or from the sun?

Meanwhile, without knowing our precise objective, we make industrial progress and we know that it all counts. We developed the art of making steel tubes until we can transport oil and gas hundreds of miles at a trifling expense. Lake and ocean vessels transport ore and coal at a low cost. Railroads are operated every year at a smaller expense in terms of mental and physical effort involved and fuel consumed. If in a century hence, means should be found for converting solar into electrical energy with only a "reasonable" loss the mechanical arts will no doubt be able to supply means for transporting the energy from the equatorial regions as far north as may be required at a much lower cost than is now involved in producing energy from coal. If that transformation has meanwhile been greatly cheapened the day of transporting solar energy will simply be postponed.

What is really important is the facilities we have at hand at present for industrial progress, for that progress will bring us to the other things. It is important for the United States that the past few years have shown that the future of the country's iron industry does not rest entirely upon the Appalachian and Lake Superior iron ore deposits. Captains of industry have proved that South America and Sweden can be drawn upon for iron ore and a very large iron industry can be built up along the Atlantic seaboard. Fuel economies and cheapened railroad transportation make the absence of coal deposits near the seaboard of less and less consequence each year, and thus rapid industrial progress is assured if men do their part.

An Untouched Asset

At the industrial conference of the late meeting of the American Chemical Society, presided over by Dr. Grosvenor, a resolution was passed urging upon the government, in effect, a census of skilled labor needed and a census of skilled labor at hand.

Whether this is possible without a general police registration of all the inhabitants we do not pretend to say. The fact that there are just so many harness-makers and so many soap-boilers in the State of New York, against so many in Illinois, would not help. What is needed is to borrow a convention from the past and add

a man's trade to his name, so that he may be classified according to this, as well as according to the letters of his patronymic. But that is not all. There is needed a large measure of invention in accountancy to bring out the information where the men of special training are. If this were accomplished so that industry might go to the swarms of common laborers and select the very men it needs so badly, and offer them the better positions and wages warranted by their training, there would be great relief all around.

The men are here by the thousand. The system of apprenticeship exists in many lands, and many an illiterate immigrant is a journeyman, if not a master at his trade. He may be working in a gang of contractors' hands on the new sewer, or on canal construction, or in the lowest order of mill work, paying tribute to the padrone or whatever the labor broker may be called in his native tongue, when he could, if put at a bench, turn out work to be proud of. The reason why we do not know where to find him is our fault, not his. We regard him as one of a bunch, and let it go at that. The poor devil has only a number, and he is lucky to have it. It is enough for us, and it is all that he can get. Since English, Irish and German immigration has ceased we have not cared very much for those Dagos and Polaks and Slavs and Greeks that have come along the plank at Ellis Island. They look foreign, act foreign, and there isn't any kind of pidgin English they can understand. Every one of them has a history, and many of them have trades, but we have claimed that we were too busy to bother about them and find out.

Now "too busy" is nearly always the lazy man's excuse. We know of a thousand acres of prime wheat land lying fallow, with wheat climbing up towards \$2 a bushel, because the yahoos that hang around the country stores "aint got no time" to cultivate it. They can all speak English well enough to understand, but they can't work. These immigrants expect to work, can and do work, but because they cannot explain what they can do best they are sent off with the gang to do their least.

There are all kinds of trades, and machinery has added some, while it has killed others. But many kinds of trade at one bench fit a man for work at another. A watchmaker, for instance, is a handy man in many different industries. A good man in a bicycle repair shop is a good man in many other places.

Generally speaking, the job that is easiest to learn is the weariest to endure, and it pays the least in the end. The man who is prepared to do any kind of work is usually the one who is bankrupt in talent or in training. On the other hand, all over the country, in mines, in gangs, wherever two legs, two arms and a strong back are needed in each unit, men are working for the minimum wage, who might be earning double and treble, to their own delight and that of their employers—if it were only known where to find them. They have learned trades which are not easy to learn—but they cannot tell about it. If industry could get into communication with the men trained according to its needs, but now at hard labor in gangs, it could increase production in a surprising measure.

Readers' Views and Comments

Water Powers of the State of Washington

To the Editor of Metallurgical & Chemical Engineering

SIR:—From recent letters in your journal the casual reader might get the impression that California is the only place on the Pacific Coast where low-cost electric power is obtainable.

According to recent government statistics, the minimum potential power obtainable within the State of Washington is 4,932,000 hp., Oregon 3,148,000 hp. and in California 3,424,000 hp., a total of 11,504,000 hp., or nearly 43 per cent of the total potential power in the United States, which is available in the three coast states. It is true that California has a larger proportion of her available power developed than is the case in either Washington or Oregon.

The Puget Sound Traction, Light & Power Company, operating in the Puget Sound district of the State of Washington, now has installed in its various plants generators with a rated capacity in excess of 105,000 hp., and they are supplying a surprisingly large number of diversified interests with power. A rate to continuous users of large blocks of power of approximately \$18 per horsepower-year is obtainable. Three electric furnaces are now being served and we are negotiating with two more. The rate to furnaces is $\frac{1}{2}$ cent per kilowatt-hour. A better realization of the rates may be had when it is known that we are now serving seven coal mines, which mines were formerly using steam. In addition, we are supplying eight lumber and sawmills in this territory with electric current. We also have one tin smelter, two antimony smelters, and a copper smelter using from 40 to 5500 hp. There are two paper mills, twelve shipbuilding concerns, six flour mills, three cement plants, in addition to one large steel works and several smaller iron and steel plants. In addition to the various manufacturing loads carried by us, we supply the current for operating about 500 miles of urban and interurban electric railways.

Our present installed capacity can be practically doubled by the installation of additional machinery at one of our power plants, which would give us a rated capacity of approximately 200,000 hp. In addition, we have undeveloped sites at which from 85,000 to 200,000 hp. can be secured, depending upon the manner in which the development is made.

There are numerous other possible waterpower developments within easy transmission distance of Seattle. There is no other place in the United States where waterpower can be so easily obtained as in this section. Locations for manufacturing plants on tide water or transcontinental railways are numerous.

While we have no electrochemical plants, it is believed that the time is most opportune for them to locate here.

Another feature of striking importance is the fact that our ocean business has increased to such an extent that the value of our imports and exports is second only to that of New York City. This business for the eight months of this year has been in excess of \$1,000,000 per day.

We have direct steamship lines to Russia, and being the closest United States port to that country, it is believed that this in itself should warrant the establishment of large concerns in this territory.

Our climate so far as working conditions are concerned is superior to that of any other part of the

United States. It is possible to work outside 365 days in the year, and the efficiency of labor here is from 15 to 20 per cent greater than in any other part of the country.

Our export business is greatly in excess of that of any other port on the Pacific Coast and is increasing very rapidly. Two of our shipbuilding plants alone have contracts for vessels totaling more than \$25,000,000, in addition to many other steel and wooden vessels under construction by the smaller shipyards.

When all these facts are realized, I believe it can readily be seen that we offer as much in the way of inducements for new manufacturing enterprises as any other portion of the country. With the numerous ores obtainable from Alaska and from the mountains in this vicinity, there should be in the near future many electrometallurgical and electrochemical plants that could be profitably operated here.

Seattle, Wash.

W. E. HERRING.

Coming Meetings and Events

American Iron and Steel Institute, Planters' Hotel, St. Louis, Oct. 27-28.

Joint meeting of N. Y. Section American Electrochemical Society and Illuminating Engineering Society, Engineering Societies Building, New York, Nov. 9.

American Mining Congress, Hotel LaSalle, Chicago, Nov. 13-18.

American Institute of Chemical Engineers, New York, Jan. 10-13, 1917.

St. Louis Meeting of American Iron and Steel Institute

The eleventh general meeting of the American Iron and Steel Institute will be held at the Planter's Hotel, St. Louis, Friday and Saturday, Oct. 27 and 28. Friday will be devoted to the reading and discussion of papers, and the banquet will be held Friday evening at the Missouri Athletic Association. On Saturday trips will be made around the city.

National Research Council

Arrangements have just been completed in New York whereby the resources of The Engineering Foundation, under the auspices of the four principal national engineering societies, are placed at the disposal of the National Research Council, which was appointed by the National Academy of Sciences at the request of President Wilson. The object of the council is to co-ordinate the scientific research work of the country in order to secure efficiency in the solution of the problems of war and peace. The council was without funds until The Engineering Foundation, established to further scientific and engineering research, offered to place its resources at the council's disposal, including the services of its secretary, Dr. Cary T. Hutchinson, to act as secretary of the council. The offer was accepted and plans for immediate activities are being made.

Chemistry is represented on the Research Council by Prof. Theodore W. Richards of Harvard, Prof. M. T. Bogert of Columbia, Dr. A. A. Noyes of Massachusetts Institute, and Dr. L. H. Baekeland. Physics is represented by Prof. R. A. Millikan and Dr. A. A. Michelson of the University of Chicago and Prof. M. I. Pupin of Columbia University.

There is also a strong representation from the great engineering societies. Clemens Herschel, president of the American Society of Civil Engineers; John J. Carty, chief engineer of the American Telephone & Telegraph Company; Gano Dunn, president of the J. G. White Engineering Corporation; C. E. Skinner, director of the research laboratory of the Westinghouse Company, and Dr. W. R. Whitney, director of the research laboratory of the General Electric Company, are among those who will represent the engineering side of the council's work.

The important military aspects will be presented to the council by Major-General William Crozier, chief of ordnance of the U. S. Army, by Lieutenant-Colonel George O. Squier, chief of aviation of the U. S. Army, and Chief Constructor David W. Taylor, U. S. Navy. Other branches of the government are represented by Dr. S. W. Stratton, director of the National Bureau of Standards, Van H. Manning, director of the Bureau of Mines, and Prof. Charles F. Marvin, chief of the United States Weather Bureau.

Open Fall Conference of Efficiency Society

"After the war, what?" An open conference on the problems confronting this country, both employers and employees alike, will be held in New York City on Nov. 16, 17 and 18, under the auspices of the Efficiency Society. At this conference leading representatives of financial, labor, manufacturing and marketing interests will give their conception of what will be the most important phases of our problem and what should be done to meet them by each element in our business life so that the activities of each may be so adjusted as to protect the welfare of all.

While the conference is brought about by the Efficiency Society, it is an open conference in spirit as well as name. All who are interested are cordially invited to attend. We expect that your own desire to learn and to help will insure an acceptance of the invitation.

The program of the first session on Thursday afternoon, Nov. 15, is to be "present foreign conditions and their prophecy." It is planned to present existing conditions abroad in such a way as to give a concise and vivid mental picture of the probable attitude of the principal countries as it may affect our industrial and commercial progress: Russia, Germany, England, France, Latin America, the Far East.

In the second session, on Thursday evening, Nov. 16, an analysis will be given of the present industrial and commercial situation in the United States as a basis for the third and fourth session. The topics to be discussed are finance, marketing, manufacturing, labor.

In the third session, on Friday afternoon, Nov. 17, the survey of the future will be begun. Conditions in this country at the close of the war as the outgrowth of the present situation here and the future abroad, will be viewed from the standpoints of finance and marketing.

In the fourth session, on Friday evening, the survey of the future will be continued, viewed from the standpoints of manufacturing and labor.

In the fifth session, on Saturday morning and afternoon, Nov. 18, an attempt will be made to plan a course of action. How shall we meet the situation? What is the attitude of each group towards the problem and towards the other groups? What is the suggestion of each group for a constructive program? The groups in question are finance, government, marketing, manufacturing, labor.

The Conference Committee consists of Willis B. Richards, chairman; Miles M. Dawson, Lee Galloway, Frederick W. Keough, Harlow S. Parson, Hickman Price. Mr. M. L. Havey, 52 Broadway, New York City, is the secretary.

Second National Exposition of Chemical Industries

The official attendance figures for the second great Chemical Exposition show quite an increase over last year. The average daily attendance was about 13,000, as compared with a little over 10,000 last year. This is an increase of 30 per cent. As was expected, the last day was the biggest in the matter of attendance on account of its being Saturday. Wednesday, Thursday and Friday were also big days with large attendances, and it is probable that more chemists attended on these days than on Saturday. The total attendance was 78,000. The motion picture hall with 500 seats was always well filled, and great interest was shown in the pictures.

The managers of the exposition report that one half the space on the main and second floors has already been taken for next year, and some space on the third floor has been taken. It is the policy of the management to give each exhibitor preference first on his own space for the next exposition, and then on other space he may select.

At a meeting of the Advisory Committee, held on Saturday night of the exposition week, it was decided that if possible a South American section should be included next year. The "Southern Opportunity" section and "Paper" section will be continued.

To supplement the full report of exhibitors and exhibits, given in our last issue, it should be stated that the General Chemical Co., New York City, exhibited C. P. and photographic chemicals and dye intermediates made at their Baker & Adamson works in Easton, Pa. It also showed samples of synthetic ammonia, ammonium salts and nitric acid. The remainder of the space was devoted to a sitting-room for the convenience of visiting chemists and their ladies, and the tea-room, in white and blue, conducted by the food department, where materials going to make Ryzon baking powder were exhibited.

Newport Chemical Works, Milwaukee, Wis., exhibited a group of "American made" coal tar crudes and intermediates, including alpha naphthylamin, nitro naphthalin, phenol, toluol, benzol, solvent naphtha, xylol and naphthalin. There was also an exhibit of turpentine and rosin.

Industrial Conferences at the Exposition

The industrial conferences which were held at the exposition and at the Chemists' Club, under the auspices of the American Chemical Society, attracted large attendances.

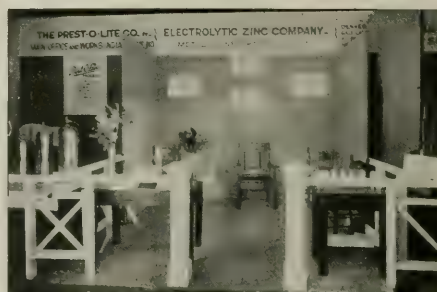
On Wednesday afternoon the conference was on "Electric Furnace Steels and Alloy Steels," with Dr. JOHN A. MATHEWS presiding. An account of this conference will be found on page 448 of this issue.

CHEMICAL GLASS AND PORCELAIN

On Thursday afternoon ARTHUR H. THOMAS presided at a conference on glass and porcelain for chemical use. Mr. Thomas said that before the war, with the exception of one large factory in the United States, which made, in addition to extensive products in other lines, a few flasks and beakers of excellent quality and reasonable price, hollow glassware for the laboratory was purchased exclusively in Europe. The American production was not, in any commercial sense, a factor in the situation.

Five factories in the United States are now regularly making flasks and beakers in large quantities. The glass used by one of these is superior in several important physical characteristics to that used for similar vessels by the European factory whose flasks and beakers have been heretofore considered the best in the world.

The four other makers are using a resistance glass



Exhibits at Second National Exposition of Chemical Industries

much alike in physical characteristics which, while not quite equal to either the American or European product above referred to, is unquestionably superior to the glass generally used throughout Germany and Austria. There are two other American factories making flasks and beakers about which he has no definite information from actual tests.

He said the output is far from sufficient to satisfy the demand, and also advocated a duty on the glass and porcelain formerly imported in enormous quantities for routine student work. The most important consideration is an unselfish coöperation between the manufacturer, dealer and chemist.

Dr. T. B. Freas, of Columbia University, spoke on the subject of the "Decreased Supply of Glassware," and said that while our manufacturers have greatly improved the situation, they have not gone far enough. Scientifically trained men must be placed in charge of the industry. One of the greatest needs is in the microscope industry, which ought to be developed in this country to a greater extent. Our manufacturers should be protected after the war.

E. P. Sullivan, of the Corning Glass Works, said that the manufacturers of this country could compete with Germany if given sufficient time.

Prof. A. W. Smith, of the Case School of Applied Science, suggested that State laws be changed so that State schools should buy their glass from the lowest American bidder instead of simply the lowest bidder.

A. B. Davis, of Eli Lilly Company, had an interesting talk on glass blowing and showed a number of pieces made in his laboratory. He said it was possible to teach glass blowing in a short time, and that our colleges should teach it. The equipment consists simply of a blast lamp, pair of scissors and a file.

PAPER AND PULP

A conference on "Paper Pulp and By-Products" was held Friday afternoon, at which ROBERT B. WOLF presided.

MISCELLANEOUS CHEMICAL INDUSTRIES: CONVERTIBILITY OF PLANT

On Saturday afternoon a conference was held on the above subject, at which Dr. WILLIAM M. GROSVENOR presided. Dr. Grosvenor in opening the discussion said that convertibility of plant means convertibility not only to a specific occupation, but such convertibility as will permit, if possible, the re-convertibility into munitions of war. The government is beginning to realize that we must hold together the nucleus of some of these industries that have been developed here or we will have to pay dearly for our oversight when the time should come.

The metallurgical industry has taught the chemists a great deal, in that they got together and not only told their problems, but told their solutions, and the metallurgical industry has advanced rapidly. He said chemists are too secretive. In reply to a question as to how to relieve this situation he said it was a matter of growth in which the Chemical Society was a step in the right direction. The American Institute of Chemical Engineers could perhaps do more, as its members have a greater degree of freedom, being those in charge of the industries, in one capacity or another. The Army and Navy Bureau has collected information on 16,000 plants which are manufacturing material required for military purposes.

Mr. Massie asked whether there was any bureau, either private or governmental, which classified workers so that skilled people would know where they were needed.

Mr. Jordan thought something ought to be done all

over the country in this direction, and offered a resolution that the society urge upon the government to coöperate with it in making such investigations. Mr. Massie offered a similar resolution and both were adopted. Mr. Potter suggested that a committee be appointed, and a motion to this effect was passed.

American Dyestuff Manufacture

At the conference on dyestuffs held at the Chemists' Club on Wednesday afternoon, several interesting discussions took place. Dr. CHAS. H. HERTY presided.

Henry Wigglesworth, of the General Chemical Company, questioned whether or not conditions in this country were favorable to the establishment of a dyestuffs industry. In European countries the industry is protected by government-authorized monopolies.

Dr. Thomas H. Norton, of the Bureau of Foreign and Domestic Commerce, made public the work of a year in gathering data on the dyestuffs industry, and also a tabular summary of our importations during the years 1913-1914. As originally presented, this tabular summary showed the quantity imported by each firm, but as the presentation of these facts met with general disapproval, the information was withdrawn and the company name withheld from publication.

Dr. J. F. Schoellkopf, Jr., of the Schoellkopf Aniline & Chemical Works, outlined the present and future work of his company. He said 50 colors were carrying the burden of 1000 imported before the war. On January 1, 1916, his company was making 1,000,000 lb. of colors *per month*, whereas before the war they only had capacity for producing 3,000,000 lb. *per year*. There are now in the course of erection additions to the plant which will bring the capacity up to 30,000,000 lb. *per year*, or one-half the amount which government statistics say is used in the country. After January 1, 1917, fifty colors will be made, whereas early in 1915 only fifteen were made, as no intermediates came in from Germany.

Mr. Dow stated that the omission of the specific five-cent duty from indigo, whereby the only remaining protection was 30 per cent ad valorem, put indigo makers in a very unenviable position as compared with the other dye makers, for the reason that an ad valorem duty automatically loses its protective feature at the very time it is most wanted because a lowering of the price abroad during trade war, also lowers the amount of duty and makes it relatively easy for the foreigner to compete, and put the unexperienced, new American industry out of business. Mr. Dow also explained the present status of their indigo plant at Midland, Mich., and stated that the plant would soon be producing commercially.

Dr. Mathews introduced a resolution that the American Chemical Society investigate the American dyestuff industry as a possible source of dyes for use by the Bureau of Engraving. Resolutions were also passed protesting against the exemption of indigo and alizarine in the dyestuff tariff section of the revenue bill. Indigo, alizarine, medicinals and flavors are exempt from the specific duty of 5 cents per pound imposed on aniline colors, and this feature of the bill, signed last month, has met with great disapproval.

Chemistry of Gas Lighting.

A joint meeting of the New York Section of the American Electrochemical Society and the Illuminating Engineering Society will be held on Thursday evening, Nov. 9, at the Engineering Societies Building, New York City. Papers will be presented on high pressure gas for lighting and on the new flexible mantle.

Wilmington Decision in Miami Flotation Suit

On Sept. 29, 1916, U. S. District Judge Bradford handed down a decision at Wilmington, Del., in the case of Minerals Separation, Ltd., plaintiff, vs. Miami Copper Co., defendant.

The hearings in this case were concluded on May 27, 1915, and a report of the hearings, with a review of the stand taken by both sides in the suit, was published in our Vol. XIII, page 409. Miami Copper Company is sued by Minerals Separation for infringement of three patents: 835,120; 962,678; 1,099,699.

Judge Bradford finds in his decision that the reduction of oil to less than 1 per cent is patentable. He sustains and declares infringement of claims 1 and 12 of patent 835,120 and all claims of 962,678. He declares invalid claim 9 of patent 835,120 and all claims of 1,099,699.

We herewith publish Judge Bradford's decision practically in full:

The bill in this suit was brought by the Minerals Separation, Limited, a corporation of Great Britain, against the Miami Copper Company, a corporation of Delaware, charging infringement of three United States process patents relating to ore concentration, owned by the plaintiff, namely, No. 835,120, of Nov. 6, 1906, to H. L. Sulman, H. F. Kirkpatrick-Picard and J. Ballot, No. 962,678, of June 28, 1910, to H. L. Sulman, H. H. Greenway and A. H. Higgins, and No. 1,099,699 of June 9, 1914, to H. H. Greenway, assignor to the plaintiff.

Review of Concentration and Flotation Processes

Under the processes shown in the three patents a signal advance has been made in the art of ore concentration in point of simplicity, economy, and efficiency, and in their practice large commercial success has been realized. Ore concentration in metallurgical operations is the separation of the metalliferous or metallic part of the ore from the non-metallic and worthless material, known as gangue, found associated with it in nature, in order that the valuable mineral or metallic particles may be in proper condition for the subsequent process of smelting. The ores to which the process of the patents in suit are applicable are mainly chemical compounds of metal and sulphur, copper sulphides, zinc sulphides, or lead sulphides.

Prior to the invention or rather discovery covered by the first patent in the suits concentration had assumed a number of forms differing from one another in the principle of their operation, but all of them requiring, as do the processes now practised, as an essential condition of the separation of the mineral from the gangue, the crushing or grinding of the ore into particles of such a degree of fineness as to produce useful results. The ore having been so crushed or ground was subjected to treatment to secure the desired concentration; such treatment varying, according to the particular process employed.

In what was known as water or gravity concentration the ore was mixed with water forming the ore pulp, and through shaking or agitation of the pulp by well-known devices the metallic particles, becoming separated from the particles of gangue, and having greater specific gravity than the water, sank to the bottom, while the particles of gangue, having less specific gravity than the mineral particles, although greater than that of the water, were subjected to an up-current, not strong enough to prevent the metallic particles from sinking, but strong enough to carry the particles of gangue to the surface where they would escape over the edge of the containing vessel or be otherwise disposed of. Such processes, however, were far from commercially successful, being wasteful of water, of power and of a considerable proportion of the metallic particles in the slimes which were carried by the up-current to the surface and were lost with the gangue.

Without pausing at this point to consider other processes of ore concentration disclosed in the prior art, hereinafter discussed, an important and, indeed, vital difference between water or gravity concentration under such processes as those above referred to, on the one hand, and concentration under the processes of the patents in suit, is that while in the former the metallic particles after being separated from the gangue in the ore pulp sank to the bottom, in the latter the metallic particles coated with an extremely thin film of oil, become attached to air-bubbles in the ore pulp, and the

bubbles with the attached metallic particles rise to the surface, forming a mineral froth of such coherency and permanency as to afford full opportunity for its removal from the surface for further treatment of the metallic particles.

The ore pulp in the process of each and every of the three patents in suit consists of a mixture of water and crushed or pulverized mineral ore, together with one or more other ingredients. In each the agitation of the pulp coupled with the introduction of air into it develops and distributes throughout the mixture small bubbles of air which attach themselves to the metallic particles, to the exclusion of gangue, and rise with them and form a metallic air froth on the surface, readily removable therefrom, the gangue particles sinking to the bottom and being disposed of as refuse. . . . [Quotation from Patent 835,120.]

The charge of infringement of patent No. 835,120 is restricted to claims 1, 9 and 12, as follows:

"1. The herein-described process of concentrating ores which consists in mixing the powdered ore with water, adding a small proportion of an oily liquid having a preferential affinity for metalliferous matter (amounting to a fraction of one per cent of the ore), agitating the mixture until the oil-coated mineral matter forms into a froth, and separating the froth from the remainder by flotation."

"9. The process of concentrating powdered ores which consists in separating the mineral from the gangue by coating the mineral with oil in water containing a small quantity of oil, agitating the mixture to form a froth, and separating the froth."

"12. The process of concentrating powdered ores which consists in separating the minerals from gangue by coating the minerals with oil in water containing a fraction of one per cent of oil on the ore, agitating the mixture to cause the oil-coated mineral to form a froth, and separating the froth from the remainder of the mixture."

The first patent in suit is for what is known as an air flotation process, in which, owing to the use of a frothing agent in conjunction with such agitation of the ore pulp as will distribute the metallic particles of the ore throughout the mixture and produce bubbles of air and bring them in contact in the mixture with the metallic particles so distributed, the bubbles will become attached to such metallic particles, carrying them separate from the particles of gangue up through the surface of the mixture where they can readily be collected by skimming, overflow, or the use of other well known devices. In this process the frothing agent consists of an oil or other immiscible substance or material of an oily nature, and the bubbles and metallic particles become attached to each other through affinity between the bubbles and the metallic particles enhanced by the coating of the latter with an extremely thin film of oil.

The old water processes of ore concentration were in some features gravely objectionable. Under those processes it was desirable to avoid very fine grinding of the ore as being calculated to cause the fine particles containing metal constituting the slimes to escape with gangue particles and be lost, such fine metallic particles, as before stated, not sinking so readily and quickly as those which were larger. In those processes there were two things to be avoided; first, the crushing or grinding of the ore to such a degree of fineness as to lead to the loss of metallic particles through their escape with gangue particles, and secondly, too coarse a crushing or grinding whereby particles of ore containing both metal and gangue might, with the gangue preponderating, too readily be carried to the surface and lost with the other gangue particles.

The defendant admits in its brief that the air bubbles collect the metallic particles, and the oil or other modifying agent in the mixture gives permanency to the mineral froth; that the attraction of the air bubbles for the metallic sulphide particles leads to the separation of those particles from the gangue; that in the absence of oil or other modifying agent in the pulp, facilitating the formation of air or other gas bubbles, no process of ore concentration employing such bubbles is possible; that air flotation may be brought about (1) by introduction of air at the bottom of the mixture or sub-aeration; (2) by beating air into the mixture or supra-aeration; (3) by generating of gas or liberation of air in the mixture.

But there is an accentuated difference of opinion between the parties on the point of preferential affinity of oil for metallic particles as compared with gangue. The defendant in its brief stated that "in ore flotation processes the oil or other modifying agent does not have any more attraction for the metallic particles than for the gangue." This position, however, is in conflict with evidence on the part of the defendant, with the evidence on the part of the plaintiff, with the documents of the art, and with the result of the physical demonstrations made by both parties in open court. . . . [As illustrations of this statement the Court quotes from Cattermole process patent 777,273, Haynes British patent 488 of 1860, Emerson patent 348,157, Fryer Hill Publication, Oct. 30, 1889, Sulman and Picard patent 793,808, Calif.

Journ. of Techn., Nov., 1903, Kirby patent 838,626, Sulman patent 835,143.]

Patentability of Reduction of Oil to Less than One Per cent

One of the principal questions in the case is whether patentable invention was involved in the discovery that the minute proportion of 0.1 per cent of oil to the ore was sufficient for commercially successful operations in ore concentration. On this question I had some doubt during the presentation of the case. But that doubt has since been removed. Sulman, Picard and Ballot had for more than two years prior to March, 1905, been interested in conducting ore concentration under what was known as the "Cattermole process," and had been seeking to improve the same in such manner as to render it more efficient and less expensive. There was a number of patents relating to this process, using the term in a general sense, among which were No. 763,259 of June 21, 1904, No. 763,260 of June 21, 1904, and No. 777,273 of December 13, 1904, all to A. E. Cattermole. In the process of each of these patents metalliferous granules are formed and separated from the gangue and fall to the bottom, while the gangue is carried up and away. In No. 777,273, the patentee states:

• • • "The proportion of oil used depends upon its viscosity, the fineness of the ore and other factors, and the consistency and size of the mineral granules desired. The more oil used, the larger, softer, and less numerous the granules. With, say, 10 per cent of oil to the weight of metalliferous mineral a few pasty masses of oil-agglomerated metalliferous mineral matter will generally result. Oil in excess of this may cause all the granules to coalesce into one soft mass. Usually an amount of oil varying from four per cent to six per cent of the weight of metalliferous mineral matter present in the ore yields granules of suitable size, consistency, and specific gravity for ready separation from the gangue in the upcurrent, or other apparatus used for classification."

All of the claims of patent No. 777,273, are restricted to a process by which the oil-coated metalliferous matter is agglomerated into granules and the granules by classification separated from the gangue. And the same is true of all the claims of patents No. 763,259, and No. 763,260, above mentioned. It is also true of both claims of patent No. 777,274, of Dec. 12, 1904, to Cattermole, Sulman and Picard. Shortly before March, 1905, Sulman, Picard and Ballot instructed A. Howard Higgins, one of the plaintiff's experts, to investigate by experiments, certain points in their bearing upon the Cattermole process of granulation. They were as follows:

- (1) Influence of acidity on granulation,
- (2) Influence of temperature on granulation,
- (3) Influence of speed of Gabbett agitation on granulation,
- (4) Influence of ratio of ore to liquor on granulation,
- (5) Influence of metallic salts on granulation,
- (6) Influence of the size of particles and of the influence of slimes on granulation,
- (7) Influence of the amount of oil on granulation."

And the above points were to be determined on "(a) oleic acid, (b) residuum oils." In consequence of his investigations Higgins made a report March 16, 1905, on granulation as affected by the percentage of oil used, in which he said:

"The effect of diminishing the percentage of oleic acid is to alter the type of oiling; the higher percentages producing granules, and the lower ones froth. Six per cent of the oleic acid on the mineral is sufficient to form good granules without much froth. This froth consists of insufficiently oiled mineral mixed with large quantities of air. As this percentage of oleic acid is decreased, the time for clean-up of the sands is increased and more froth is formed. 0.62 per cent oleic acid on the mineral is insufficient to form any granules and nearly the whole of the mineral comes to the surface, on stopping the cone, as froth. 0.2 per cent acts in the same manner, leaving the coarse sands with rather more mineral in them. (This is 0.1 per cent on Broken Hill ore.) In all cases the oil has been measured in cubic centimeters and the percentage calculated as though they weighed grams, but as the specific gravity of the oleic acid is less than unity, this is not the case, and all percentages will be lower than those actually given."

There was, I think, patentable invention in the discovery thus made in March, 1905. Prior to that time there has been no suggestion in the art that the proportion of 0.1 per cent of oil to ore or of any other fraction of 1 per cent of oil to ore would or might result in successful concentration.

Further, the result reached was an utter surprise. Experiments were conducted with reference to the Cattermole process, and all of the Cattermole patents required the formation and sinking of granules containing the metallic particles, and not their flotation. The teaching of that process was that the metallic particles should go to the bottom and that of the process of the first patent in suit that they should go to the top.

But while the ascertainment that such a minute proportion of oil would effect a successful concentration of ore through a flotation process was a discovery, it was nevertheless of such a character, viewed with respect to the circumstances under which it was made, as to involve invention and confer patentability.

The statutes provide for patenting new and useful inventions and discoveries, but a bare discovery unaccompanied by the exercise of any invention in reaching it or utilizing or reducing it to practice would not justify or support a monopoly in the discovery. In the present case, however, the facts disclose not a bare discovery, but a discovery coupled with invention in usefully applying it. In such cases patents properly may be granted.

The defendant lays much stress upon the proposition that the reduction of the amount of oil in the process for the concentration of ore did not and could not involve patentable invention, but only an ascertainment of the proper degree in which oil should be used, which was readily discoverable by any one competent to conduct or superintend a process of ore concentration; and further, that motives of economy would naturally have suggested a reduction in the quantity of oil to the extent of its excess over what was necessary for the accomplishment of the purposes of the process.

But if such a reduction was obvious, why is it that it was never made prior to the discovery in question? The fact that economy required the use of the least quantity of oil sufficient for the conduct of the process affords cogent evidence that the feasibility of effecting a reduction was not obvious, but properly the subject of patentable invention.

No one to-day understands how the use of only 0.1 per cent of oil operates to secure the mineral froth of the first patent in suit. This is testified to by the experts and is admitted on both sides. If the principle of operation of the discovery is insolvable to the human mind to-day it could not have been predicted or anticipated by the human mind in March, 1905. The fact that the underlying principle of the process was not understood by no means negatives patentability. . . . [Quotations from Diamond Rubber Co. v. Consol. Tire Co. 220 U. S. 428.]

This case is unlike those in which the discovery of the use of an element in a process in the degree insuring the best results is a matter within the competency of those skilled in the art, but, on the contrary, is one where clearly there was patentable invention or discovery in ascertaining the degree. The experiments made with respect to the Cattermole process were initiated with a view to its improvement and the securing of granulation of a higher efficiency. The prosecution of the experiments relating to a sinking and not a flotation process would naturally tend to divert the mind from the contemplation of any process of the latter character. . . . [Quotation from testimony of Mr. Higgins.]

I perceive no escape from the conclusion that the discovery was patentable. To decrease the amount of oil used in an old process, so long as the characteristic mode of operation and result of such process are preserved, even though in less degree, does not as a general rule involve invention. But when the old mode of operation and its result through a decrease in the amount of oil disappear and a new and different result is disclosed, the change ceases to be one of mere degree, and may support a patent monopoly in favor of one whose inventive genius or research has discovered the process. The patentability of the process of the first patent in suit resides in the use of only the minute quantity of oil contemplated by the patent. The reduction of the oil to this quantity effected a change, not merely in the degree, but in the "type of oiling," leading to results which cannot be accounted for on the assumption that a mere change in degree as distinguished from patentable discovery was involved.

The defendant contends that a substantial increase in the amount of oil used will not affect the nature or efficiency of the process of separation, but will only add to the cost by carrying it on with an unnecessary amount of oil. But this position is in conflict with the decided weight of the evidence and with the showing of the experiments conducted by Higgins at and immediately prior to the time of the discovery. It is satisfactorily proven that the process of the first patent in suit, depending upon the selective affinity of the air-bubbles in the mixture for oil-coated metallic particles, that affinity is strongest when the film of oil surrounding the metallic particles is so thin as to be imperceptible to the senses, and that with any substantial increase in the quantity of oil on the metallic particles the character of the process is changed and its efficiency diminished for some reason as yet unrevealed.

A great advance in the art of ore concentration has re-

sulted from the process of the first patent in suit in the efficient recovery of slimes. With the use of that process ore may be so finely ground as to insure the thorough separation of the metallic particles and gangue, and great savings effected. The profit so saved in a single year from the output of the principal porphyry copper mines, including the defendant's, has been estimated by one of the expert witnesses as more than \$17,000,000. . . . [Quotation from Moore Filter Co. v. Tonopah-Belmont Development Co., 201 Fed. 532,540.]

Alleged Anticipations

The defendant sets up as part of the prior art to negative invention United States patent No. 689,070 of Dec. 17, 1901, to A. S. Elmore. This patent was for an "Improvement in separating mineral substances by the selective action of oil," and contains but one claim as follows:

"The process for separating metallic and rocky constituents of ore which consists in mixing pulverized ore with water and mixing the ore and water with oil in the presence of an acid, allowing the mixture to rest, whereby the oil having the metallic substances entrapped in it floats at the top of the mixture, and separating the metallic constituents from the oil, substantially as described." * * *

The patent nowhere states the amount of oil which is to be used or the ratio between the weight of the oil and the weight of the ore or its metallic content. It, however, clearly appears from the evidence that the process was what has been termed a "bulk oil process," employing from one to two and a half or three tons of oil to each ton of the pulverized ore to be treated. By reason of the large amount of oil used and the loss of a considerable proportion of it in operation the process was expensive and unsatisfactory. There was but a small recovery from the slimes, probably for the reason that the extremely minute metallic particles contained in them did not yield to centrifugal action employed in the separation as readily as the larger particles.

The Elmore bulk oil process was litigated abroad in *Minerals Separation, Ltd., v. British Ore Concentration Syndicate, Ltd.*, which was an appeal to the House of Lords by the plaintiff herein from a judgment of the Court of Appeal, holding that it had infringed the A. S. Elmore British patent No. 11,307 of 1901, corresponding substantially with United States patent No. 689,070 of Dec. 17, 1901, to A. S. Elmore. The judgment of the Court of Appeal was reversed by the House of Lords. The opinions delivered to that house differed with respect to the validity of the A. S. Elmore patent, but it is to be gathered from the opinions so delivered that the plaintiff herein was held by the House of Lords not to have infringed. . . . [Quotation from Lord Shaw.]

The process of the first patent in suit was also considered in *Ore Concentration Company, Ltd., v. Sulphide Corporation, Ltd.*, in the Supreme Court of New South Wales, and an appeal in the Privy Council of Great Britain. The action in the court below was brought by the owner of and a licensee under British patent No. 10,001 of 1900, to F. E. Elmore, and British patent No. 11,307 of 1901, to A. S. Elmore, to restrain the infringement thereof by a licensee of the plaintiff herein conducting the process of the first patent in suit. The suit was abandoned at the trial with respect to the F. E. Elmore patent, and was dismissed by the Court below as to the A. S. Elmore patent, July 24, 1911.

On appeal the Privy Council affirmed the judgment of the court below, March 6, 1914. The case turned on the questions of the validity of the A. S. Elmore patent and its infringement by the licensee of the plaintiff herein, no reference being made to the first patent in suit or the corresponding British patent, although the novelty of the process was recognized. . . . [Quotation from Lord Parmoor on the general nature of the A. S. Elmore process.]

The judgment concluded with the statement that "their Lordships find that the respondents do not either directly or indirectly use the invention claimed by the appellants, but a process essentially distinct, and that there is no infringement."

While, as already stated, the validity of the first patent in suit was not before the court in either of the British cases, but the question of infringement by the practice of that process, the opinions delivered in the House of Lords, as well as the decision of the Privy Council in declaring that the process covered by the first patent in suit was one "essentially distinct" from the Elmore process, are entitled to much weight. It is too clear for further discussion that the bulk oil Elmore process in no way affects the validity of the first patent in suit.

The defendant sets up as an anticipation of the first patent in suit the Haynes British patent No. 488, of 1860.

I am satisfied that the Haynes patent is not an anticipation, and, equally, that as part of the prior art it cannot operate to negative invention. In the first place, aside from all other features, the patent does not limit the quantity of oil, fatty or oleaginous matter to the oil proportions of the first patent in suit, and, secondly, the patent does not require agitation of the pulp other than such as may result from the passage of the same into a "tritulating machine." And it appears from the testimony of Dr. Sadtler that without the use of some means to produce agitation not mentioned in the patent its process will not produce mineral froth flotation. Dr. Liebmman states that the process is "quite impracticable" and "quite impossible." . . . [Further quotation.]

Two patents to Edmund B. Kirby, No. 809,959 of Jan. 16, 1906, applied for Dec. 14, 1903, for an "Improvement in process of separating minerals," and No. 838,626 of Dec. 18, 1906, applied for Dec. 17, 1903, for an "Improvement in separating tanks," are relied on by the defendant as part of the prior art. The process patent recommends from 25 per cent to 75 per cent of oil to the ore, stating that "preferably the pulverized ore is mixed with three to five times as much water, by weight, and to this is added a sufficient amount of the kerosene-bitumen solution, excellent results being obtained by using one-fourth to three-fourths as much by weight as ore."

It is fair to assume that Kirby would not have specified oil to the extent of from 25 per cent to 75 per cent on the weight of the ore had he deemed it practicable or possible to do with less. An examination of the process patent and of the evidence relating to it shows, I think, that the patent contemplated an oil buoyancy flotation in contradistinction to the metallic air froth of the first patent in suit, and was for a different process, not suggestive of that of the latter, with its economical and successful use of a fraction of only 1 per cent of oil. The Kirby apparatus patent No. 838,626 is for a separating-tank intended for use in the Kirby process. In view of what has been said touching that process the apparatus patent does not call for discussion.

The defendant sets up as part of the prior art a number of patents granted to Alfred Schwarz, but offered in evidence only three of them, No. 807,501 of Dec. 19, 1905, applied for April 19, 1905; No. 807,502 of Dec. 19, 1905, applied for May 27, 1904; and No. 807,503 of Dec. 19, 1905, applied for May 27, 1904. All of these patents relate to the concentration of ores. . . . There is no evidence that any process under either patent No. 807,502 or patent No. 807,503 was carried on as part of the prior art, and evidently each of them requires the use of a larger quantity of oil than the minute proportion required by the first patent in suit; the former stating that "the selective agent being added in sufficient quantity to thoroughly saturate the ore and to make a thick pasty mass," and "the metallic constituents adhering to and being entrapped in the resinous and oil or fat compound will be buoyed up thereby and rise to the top," etc., and the latter, that "the ore is mixed with sufficient of the selective material to make a thick pasty mass, the agitation being continued long enough to bring the selective material into intimate contact with all portions of the ore," and "the mass is then allowed to subside, when the selective material, with the entrapped metallic constituents of the ore, will rise to the top," etc. There is, I think, no evidence or legitimate inference to warrant the conclusion that either of these patents can affect the validity of the first patent in suit.

The defendant also relies upon patent No. 348,157 of Aug. 24, 1886, to Carrie J. Everson, for an "improvement in processes for concentrating ores," as part of the prior art. The patent specifies two methods of conducting the process. It is admitted that the first method requires oil amounting to 5 per cent on the weight of the ore. With respect to the second method it is stated in the patent description:

"I have found three fluid drams of oil abundant for properly moistening two ounces of heavy ore or in the ratio of about a barrel of oil to the ton of ore, the amount being, of course, variable with the relative bulkiness of the ore."

Dr. Liebmman testifies that the oil used in the process was 16.5 per cent of the weight of the ore, and Dr. Sadtler says that the amount of oil so used was from 16 per cent to 17 per cent of the weight of the ore.

The Everson process has never been used commercially and Dr. Liebmman states that it could not be so used; that "it is not a process for large-scale operations"; but that there was a possibility of its application to gold and silver in small quantities. Dr. Sadtler expresses no opinion upon the applicability of the Everson process to the concentration of ore on a commercial scale, and states, in substance that he had never practised the Everson process in either of the methods disclosed in the description of the patent.

The defendant argues that in the Everson process the concentrate "could not possibly float by the bulk oil flotation principle, for the simple reason that the amount of oil was insufficient for that purpose," that with the use of only 17 per cent of oil no bulk oil flotation is possible; and that the process "could not have resulted in surface tension flotation, skin flotation or film flotation, so-called, for the simple reason that the conditions for that form of flotation were absolutely wanting."

But this contention fails, I think, to negative patentable invention in the process of the first patent in suit. I am not satisfied by any experiment or demonstration made in the case that the process described in the Everson patent would produce the economical and efficient concentration secured by the process of the first patent in suit. Certainly, were there nothing else, a reduction in the quantity of oil from 17 per cent or even 5 per cent to a fraction of 1 per cent on the weight of the ore, under circumstances similar to those attending the discovery of the sufficiency of that minute proportion for successful metallurgical operations would be sufficient to confer patentability.

An analogy is furnished in *Loom Co. v. Higgins*, 105 U. S. 580, where Mr. Justice Bradley, delivering the opinion of the court, said:

"It is certainly a new and useful result to make a loom produce 50 yards a day when it never before had produced more than 40; and we think that the combination of elements by which this was effected, even if those elements were separately known before, was invention sufficient to form the basis of a patent."

The defendant also relies upon a newspaper article taken from the *Daily Herald Democrat*, of Leadville, Col., Oct. 30, 1889, referred to as "Fryer Hill Publication," and an article taken from the *Engineering and Mining Journal* of Nov. 10, 1890, referred to as "Criley and Everson Publication," as part of the prior art. It appears that both articles refer to tests or experimental applications of the process of the Everson patent, with some slight modifications. Neither of these articles contain anything rendering it necessary to add to what has been said in direct connection with the Everson process.

Much stress is laid by the defendant upon an article in the *California Journal of Technology* of November, 1903. This article was prepared by three young men, students in the class of 1903 in the mining department of the University of California, and is entitled "Experiments on the Elmore process of ore concentration." This article is suggestive, but cannot, I think, be justly treated as negating the exercise of invention with respect to the process of the first patent in suit.

The experiments were laboratory tests and did not disclose or suggest the idea that such a minute quantity of oil as one-tenth of 1 per cent, or any fraction of 1 per cent, on the weight of the ore could be efficiently and successfully employed in ore concentration. There were a number of tests with respect to the concentration of molybdenite ore with percentages of oil to ore running from 2.1 per cent to more than 100 per cent, with the result that the highest extraction of molybdenum sulphide was obtained by the use of 8.9 per cent of oil; the extraction in that case being 75 per cent as against an extraction of 43.5 per cent obtained by the use of 2.1 per cent of oil. The teaching of these tests was that 2.1 per cent of oil was less efficient than the use of 8.9 per cent, and the article as a whole, far from suggesting the possibility of the use of only a fraction of 1 per cent of oil points to an opposite conclusion.

The defendant contends there is nothing new in the employment of only a fraction of 1 per cent of oil relative to the weight of the ore in the process of the first patent in suit, for the reason that, as alleged, an equally small proportion of oil was used in the process of the Cattermole Patent No. 777,273, mentioned in the first patent in suit.

The Cattermole patent mentions from 4 to 6 per cent in weight of oil to the weight of the metalliferous mineral present in the ore, and consequently, under the Cattermole process the amount of oil to be used depends upon the weight of the metalliferous mineral, and not upon the weight of the entire ore, and there is evidence to the effect that the larger part of the copper ores mined and concentrated in this country contain about 2 per cent of copper. Hence the argument is made by the defendant that the weight of oil employed in the Cattermole process is only from 0.8 per cent to 0.12 per cent of the weight of the copper contained in the ore, and that any proportion of oil less than 1 per cent of the weight of the ore comes within the quantity mentioned in the first patent in suit, namely, "a fraction of 1 per cent on the ore."

This contention ignores the following statement in the description of the Cattermole patent now considered:

"In certain cases, as where but little mineral is present in the ore, to increase the nucleating or granulating factor pulverized mineral matter obtained in a previous operation or other matter having an affinity for oil from a different source may be introduced into the ore, or a portion of already granulated and separated mineral matter may be returned to maintain the necessary amount of mineral in the ore under treatment."

It is evident that the weight of "pulverized mineral matter" introduced to "maintain the necessary amount of mineral in the ore under treatment" is, for the purpose of determining the necessary amount of oil to be added to "the weight of metalliferous mineral matter present in the ore." Such must be the meaning of the patent or it is insensible. And this accords with the requirement in the seventh claim of "adding particles of material having an affinity for oil to assist in the formation of granules of oil-coated particles."

The defendant has made no demonstration, as might have been done, of the amount of oil required by the Cattermole process in its application to lean copper ores, but indulges in speculation and conjecture on that point.

The defendant contends that in the Cattermole process of the above patent there were necessarily two degrees of agitation of the mixture; the first being violent and the second gentle. On the assumption that two degrees of agitation were required in the Cattermole process; first, violent agitation of the mixture in order to bring the oil into intimate contact with the mineral particles; and, secondly, the subjection of the mixture to a slower or rolling form of agitation to cause the agglomeration of the oiled metalliferous particles and the formation of granules, it by no means follows that with the omission of the second step the mineral froth of the process of the first patent in suit would have been formed, had there been in the mixture oil in excess of the proportions contemplated by that patent.

And if it be further assumed that the mixture containing oil and other elements in Cattermole proportions can first be violently agitated so as to produce a froth and then slowly agitated so as to produce granules, and again violently agitated so as to destroy the granules and restore the froth, and so on by alternation, and that the mixture remaining the same, the production of froth on the one hand, or granules on the other, is simply a matter of manipulation, it is not to be inferred that the froth so formed with Cattermole proportions of oil would be the froth of the first patent in suit.

Dr. Liebmann, for the purpose of distinguishing between the Cattermole process and that of the first patent in suit, during the trial conducted two experiments, identical in their nature, save that in one a larger amount of oil was used than in the other. In the former case granules were formed which sank; and in the latter a mineral froth was formed, the agitation and other factors being the same; 3.6 per cent of oil and 0.1 per cent of oil were respectively used in the two experiments. Both were performed in the same apparatus with similar materials and manipulation. These experiments served to show that the variation in the amount of oil used, other things being equal, may result in the formation of the mineral froth of the first patent in suit, or in the formation and sinking of the granules of the Cattermole process. In this connection it is to be observed that the Cattermole patent in its descriptive portion states:

"With certain ores it may be preferable to use in some stages of the process a rolling form of agitation, as in cylinders or barrels, to obtain good granulation of the mineral."

The description of the patent nowhere specifies that its process is necessarily dependent upon two degrees of agitation, one violent and the other slow or rolling, and in none of the seven claims of the patent, with the exception of the fifth, is such a requirement mentioned or suggested. In that claim only is there a provision for "further agitating the mass to increase the size of the granules," and even in that claim there is no suggestion of a difference in degree between such further agitation and the agitation which has preceded it. For the foregoing reasons I think that the contention of the defendant that the quantity or proportion of oil used in the Cattermole process was not materially in excess of that used in the process of the first patent in suit, and that, not a difference in the quantity of oil, but a resort to two degrees of agitation was essential to the formation of Cattermole granules, cannot be sustained.

The defendant also relies upon two patents granted to Alcide Froment; one of them being British patent to Henry Harris Lake, communicated by Alcide Froment, No. 12,778, of 1902, and the other an Italian patent to Froment, No. 63,723, the specification of which is dated May 20, 1902.

The weight of the evidence is that the quantity of oil to ore necessary for the conduct of the process specified in

the patent would amount to from 12 per cent to 15 per cent of the weight of the ore, and this seems to accord with the statements in the patent that a "kind of metallic magma" is formed and that "the metallic spherules pressed one against the other, will become grouped in a magma clearly separated from the remainder of the liquid."

These statements, I think, are inconsistent with any idea that under the Froment process the metallic particles were coated with oil of the extreme thinness, characterizing the process of the first patent in suit; the thickness of the film in that process, according to scientific evidence, being only one one hundred thousandth part of an inch and imperceptible to the senses, as compared with a thickness of from sixteen to thirty-two one hundred thousandths of an inch in the Cattermole process and from eighty-eight to two hundred and forty one hundred thousandths of an inch in the Froment process. . . . [When the Froment British patent was assigned to Ballot there was handed to him] a "description and instructions for the concentration of ores" under the Froment process. It is dated Dec. 29, 1903. The instructions recommend the use of oil in proportions varying from 1 per cent to 3½ per cent, according to the different percentages of metal in the ore.

Notwithstanding the low percentage of oil mentioned in the Froment description, I have reached the conclusion that it contained no disclosure of the process of the first patent in suit. The evidence on the subject of the Froment description is voluminous and conflicting, but there are facts and circumstances which have satisfied me that the process of the first patent in suit was not discoverable from that description by men skilled in the art of ore concentration.

There is uncontradicted evidence that Sulman, Picard and Ballot, after the assignment of the Froment British patent, and the receipt of the Froment description and instructions, made persistent efforts to operate the Froment process successfully, but only met with failure, and that the model apparatus sent by Froment to Ballot was treated as worthless and discarded or "scrapped." Sulman, Picard and Ballot were scientific men of large experience in the art of ore concentration, and had the Froment patents or description disclosed or suggested the process of the first patent in suit, it is to be assumed that they would have utilized it instead of prolonging their attempt until March, 1905, to perfect granulation under the Cattermole process. The fact that they did not utilize it affords the strongest evidence that the Froment description did not suggest a process in which the minute quantity of oil required by the first patent in suit could be successfully used in ore concentration.

The defendant relies on patent No. 793,808, of July 4, 1905, to Sulman and Picard, for "Improvements in or relating to ore concentration." . . . [Quotations from patent.]

There are certain features in this process as described, similar to features in the process of the first patent in suit. The amount of oil coating the metallic particles being insufficient to raise them through the flotation power of the oil alone, gaseous bubbles, whether generated in the mixture, or introduced into it through the perforated spiral coil, attaching themselves to the oiled metallic particles, rise to the surface with those particles, so as to be removed by skimming or other suitable means, the gangue particles remaining in the main at the bottom of the vessel containing the mixture.

This process patent, issued to Sulman and Picard upon an application filed Oct. 5, 1903, affords cogent circumstantial evidence of the patentability of the process of the first patent in suit. I have been unable to read the description of the patent immediately under consideration without reaching three conclusions; first, that Sulman and Picard had conceived an idea, though imperfect, of an air flotation of the metallic particles; secondly, that they had no conception whatever of the possibility of conducting such a process with the minute quantity of oil specified in the first patent in suit; and thirdly, that they contemplated the use of a very much larger proportion of oil.

In view of the fact that both patentees in No. 793,808, were two of the three patentees of the process of the first patent in suit, it is so improbable as to amount to a moral impossibility that for nearly a year and a half after the filing of the application for patent No. 793,808 they should have devoted their attention and efforts to the solution of the problem of the proper quantity or proportion of oil to be used in securing improved granulation in the Cattermole process, and have been astonished at the making of the discovery in March, 1905, if they had recognized or believed that an economical and efficient process of ore concentration could be carried on by the use of oil amounting to only a fraction of 1 per cent. Any further discussion of patent No. 793,808, I think, is unnecessary.

Further Discussion of Validity of First Patent

I have found nothing in the prior art to anticipate the process of the first patent in suit or to negative invention. Objection has been made to the disclosures of the patent are not sufficient, in that the application of the process to different ores necessitates some difference in treatment involving a variation in temperature, or in the amount of acid or of oil, and the patent omits to specify the degree or amount of such variation with respect to the treatment of the different ores. But to require of an inventor such a specification would be to demand an impossibility. The patent recognizes that different ores may require a different treatment. . . . [Quotation from patent.]

And claims 1 and 12 mention oil amounting to "a fraction of 1 per cent." A close or exact adjustment of quantities and proportions of oil in the treatment of different ores within the limits prescribed in the patent is a matter calling, not for the exercise of inventive genius, but for the skill of the metallurgical engineer conducting or superintending the operation. [Quotation from *Mowry v. Whitney*, 14 Wall, 620.]

Some embarrassment in the treatment of this case has been caused by the use of different adjectives and descriptive phraseology as applied to the same thing. If a patent for a process of ore concentration, or any other process, clearly sets forth the ingredients and the practical steps to be observed in conducting it the misuse of terms as applied to the operation of natural laws involved in the process is immaterial. In the administration of justice it is the aim of courts to deal with substance and not to be influenced by mere form not calculated to mislead as to substance; and where a material and substantial thing is plainly identified in the patent claims and description a mistaken misnomer is harmless and negligible. Inventors are not required to understand the natural laws under which new and useful results are obtained from ingredients, elements, apparatus and manipulation requisite for the conduct of the process.

There are occult laws, unknown and inexplicable, to which tangible results must be attributed. In the nature of things an inventor, so long as he clearly sets forth the practical means and steps for securing those results, does all that the law requires or can reasonably be expected of him. So, it is unimportant that to the same thing one name may be applied by one person and a different name by another, the identity clearly appearing. The truth of this statement has been strikingly exemplified in this case in the language of patents and other publications, judicial decisions, the oral testimony and the arguments of counsel.

During the trial a large number of experiments were made for the purpose of illustrating ore concentration processes described in patents and other printed publications of the prior art. Such experiments are illuminating and helpful, or deceptive and misleading, according to the conditions under which they are performed. As a general rule, in such experiments processes of the prior art should be illustrated by means of apparatus of the prior art in which such processes were conducted at or about the time of invention and under the conditions then understood and observed. To construct apparatus long after, and in view of subsequently acquired knowledge, in order to show a prior process, tends to produce embarrassment and confusion touching the nature and operation of the process inquired into. . . . [Quotation from *Naylor v. Alsop Process Co.*, 168, Fed. 911, and from *Schmertz Wire Glass Co. v. Western Glass Co.*, 178, Fed. 977.]

The material question for the court is not whether any given apparatus is capable, under manipulation employed in view of existing knowledge, of carrying on the prior process inquired into, but whether the process was carried on as part of the prior art, and, in case of an ore concentration process, by way of illustration, under what conditions as to ingredients, strength and extent of agitation and other essential factors; and only so far as those conditions are reproduced and faithfully observed in demonstrations in court, due allowance being made for the difference in the requirements of mill operations, is the experiment entitled to probative force. The difference between the conduct of the process in the mill and the necessarily interrupted or broken character of the process as disclosed in experiments in court and laboratory tests in subsequently constructed apparatus must be borne in mind in determining the weight to be given to such experiments or tests.

Claim 9 of First Patent Invalid

On the whole I am satisfied that the first patent in suit must be sustained as to claims 1 and 12, but not as to claim 9. The two former are definite, specifying and limit-

ing the amount of oil to be used; claim 1 mentioning "a small proportion . . . amounting to a fraction of one per cent on the ore," and claim 12 "a fraction of one per cent of oil on the ore." Claim 9 mentions "a small quantity of oil." This is so indefinite as to render the claim void, unless on consideration of the patent as a whole the claim can by construction be limited to the use of oil amounting to only a fraction of one per cent.

The patentability of the process of the first patent in suit resides in the use of oil in the extremely minute proportion disclosed in the descriptive portion of the patent to effect separation of froth with its metallic particles from the remainder of the mixture by flotation. The amount there disclosed is not in excess of "a fraction of one per cent on the ore" and may be only one-tenth of one per cent of the ore, or even less.

If, then, by construction claim 9 should be so limited as to be restricted to the use of oil amounting to only a fraction of one per cent on the ore, that claim is in substance, though not in exact phraseology, the same as claim 1 for the reason that in any event from the nature of the invention it would be necessary to read "by flotation" into claim 9, if in other respects valid. But a limitation by construction producing such a result is inadvisable.

It is suggested by one of the plaintiff's counsel in his consideration of claim 9, that one for the purpose of securing immunity from the consequences of infringement might use an oil useful in the process, and add to it an oil not useful as applied to his particular ore, and, on being sued for infringement contend, "I am using 1.1 per cent of oil. I did not infringe. I am using more than a fraction of 1 per cent of oil." But the existence of this possibility does not, I think, warrant such a construction of claim 9 as is urged; for the disclosure of the patent does not extend to the use of 1.1 per cent of oil, but is limited to a fraction of 1 per cent. If it be assumed, however, that the claims in suit contemplate and require the use of efficient, as distinguished from inefficient, oil, and if in the case suggested an inoperative oil should be used by way of addition to the efficient oil so contemplated and required it might be a question, upon which, however, no opinion is here expressed, whether the addition of the inoperative oil to the efficient oil could be treated as an increment to the amount of oil so contemplated and required, operating as a shield to protect the wrongdoer. But this question would arise in a suit based upon claim 1 or 12, as well as in a suit based upon claim 9, were it proper by construction, in order to save it, to limit "a small quantity of oil" to a quantity of oil amounting only to a fraction of one per cent on the ore, and therefore fails to require or justify the suggested limitation of claim 9, without which it must fail.

Infringement of First Patent

On the question of infringement of the first patent in suit I have no doubt. It was practically admitted by counsel for the defendant in opening the defense that it had infringed the three patents in suit by its operations at Miami within four months next before the filing of the bill; he stating "in the first installation which was made at Miami, we make no serious contention that it did not represent the operations set forth in the three patents in suit." It appears that the infringing operations were carried on in apparatus built in imitation of the plaintiff's standard machine.

But the defendant denies that it infringed by its concentration of ore in its pneumatic flotation plant through its practice of the process of patent No. 793,808 of July 4, 1905 to Sulman and Picard, hereinbefore discussed, as modified by the use of what is known as the Callow cell. Counsel for the defendant, however, stated with respect to the process of the patents in suit and the process as carried on by the defendant under the Sulman and Picard patent, with the apparatus of the Callow cell:

"The broad principles are the same in both. In both we have the pulp, consisting of ore held in suspension in water. In both the water is modified to lower its surface tension. In both the buoyancy comes from air-bubbles."

The defendant in its operations also used the minute proportion of oil mentioned in the first patent in suit. It does not use acid in its process; but this fact is immaterial so far as the question of infringement is concerned for the reason that it appears both from the claims and the description of that patent that the use of acid is optional, the description stating that "the water in which the oiling is effected is preferably slightly acidified," and claims 1 and 12, as well as claim 9, unlike a majority of them, not requiring acid. The defendant's counsel also stated that the difference between its process and that of the complainant

"comes after the air-bubbles have attached themselves to the mineral particles."

I do not think there is any such difference between the processes as to negative infringement. It was in substance admitted on the part of the defendant that if the first patent in suit is a pioneer patent and properly drawn the operations carried on at Miami were an infringement. Whether that patent is technically a pioneer patent or not, it certainly was highly meritorious and, I think, partook of the nature of a pioneer patent so far as the very successful use of oil amounting to only a fraction of one per cent is concerned. Its claims merit much liberality of construction and when so construed embrace the operations of the defendant at Miami.

The purpose of each process is the concentration of the ore through the separation of the metallic particles from the gangue. In the plaintiff's process the separation is effected through the rising of air-bubbles to which are attached the metallic particles, through the mixture to the top, and the formation of a froth or scum on the surface, which can by simple means be removed with the contained metallic particles. In the defendant's process the separation is effected through the rising of air-bubbles to which are attached the metallic particles through the mixture to the top and the floating away into a launder of either the original bubbles to which the metallic particles were first attached or succeeding and oncoming bubbles which have caught and buoyed up to the surface the metallic particles escaping from bursting bubbles. By the use of a launder a recovery of the metallic particles is readily effected.

The defendant contends that since its abandonment of its original infringing process at Miami above referred to, it has not and does not infringe the first patent in suit, for the reason that it does not in its process produce the coherent and permanent froth of the process of that patent. It appears from the evidence, it is true, that the bubble froth in the defendant's process is not as coherent and permanent as the froth of the process of the first patent in suit; but both are mineral froths, and that of the defendant is sufficiently permanent to effect through air flotation an efficient separation of the metallic particles from the rest of the mixture. Air-bubbles, however produced, in water not modified or contaminated—pure water—on reaching the surface will immediately collapse, and the formation of bubble or air froth is impossible; but air-bubbles in modified water will not instantly disappear on gaining the surface. The degree of their permanency after reaching the top largely depends on the degree of modification of the water.

There has been much expert evidence relating to the subject of surface tension to the effect that in the case of pure water it is so great as to cause the instant collapse of bubbles of air rising to the surface; but that through modification of the water, the tension is so reduced in force as to permit the continued existence for a greater or less period of bubbles of air reaching the surface. The water in the ore pulp of the defendant's process is strongly modified and of necessity the bubbles on reaching the surface do not and cannot instantly disappear; but, on the contrary, in accordance with the operation of natural laws about which there is no conflict, persist and continue on the surface as a bubble or air froth. But whatever may be the true explanation of the phenomenon of the continuance and disappearance of escaping bubbles, the fact remains that the defendant's process discloses a froth consisting of bubbles which have passed through modified water to the surface of the mixture, and float thereon, and with their freight of metallic particles flow over the edge of the containing vessel into a launder, thus effectively separating the valuable mineral from the gangue particles. Coherency and permanency in a froth admit of degrees, and such a degree as insures by air flotation efficient and final separation between the metal and the gangue, whatever may be the duration of the froth, comes within the process of the first patent in suit.

The defendant further insists that its process lacks violent agitation which it claims is an essential of the process of the first patent in suit. Each of the twelve claims of the patent mentions as an element of the process "agitating the mixture," but not one of them mentions violent agitation. It is, however, urged that as the descriptive portion of a patent for a process must contain a full and fair disclosure of the patented invention the claims must be read in the light of the description, and as violent agitation is included in the description the claims with respect to agitation must be limited to violent agitation. But the description nowhere mentions "violent agitation" or uses any equivalent expression. It mentions "vigorous agitation," and states that in the case of the application of the patented process to an ore containing "ferruginous blende, galena, and gangue consisting of quartz, rhodonite, and garnet,"

the mixture is "briskly agitated." It also describes as a part of the apparatus for carrying on the process a "rotatable stirrer." But I do not find in the description any specification of any rate of speed for the rotatable stirrer, or of any standard for the determination of what constitutes a "vigorous agitation" of the mixture, or a specification of any test for ascertaining whether the mixture is "briskly agitated."

All these matters were left to the judgment and skill of the metallurgical engineers conducting or superintending the operation of the process, involving empirical investigation to reach the best results. The strength of agitation referred to in the description clearly admits of different degrees, varying from one another in the application of the process to different ores and under changing conditions. There is no room for doubt that agitation of the mixture in the process of the defendant is sufficiently vigorous or brisk to insure efficient ore concentration by an air flotation process such as is accomplished by the complainant by agitation under the process of the first patent in suit. This being true the use of mere adjectives in the descriptive portion of the patent with respect to agitation is unimportant.

In order that the bubbles in the pulp mixture may come in contact with the metallic particles there must be such movement between them as cannot be wholly accounted for by selectivity as between them, and their movement so far as not accounted for by selectivity is the result of agitation; and whether such agitation results from the stirring or beating of the mixture or the forcing or admission of air in it is immaterial; for what this court is dealing with is not an apparatus patent but a process patent.

Callow Pneumatic Flotation

Patent No. 1,104,755 of July 21, 1914, to John M. Callow, covers apparatus relating to ore concentration. The evidence shows that the defendant in its concentration of ore in its pneumatic flotation plant employs the process of patent No. 793,808 of July 4, 1905, to Sulman and Picard, hereinafter discussed, as modified by the use of certain apparatus substantially the same as a portion of the apparatus, the operation of which is described in the above-mentioned Callow patent, as follows:

"From the foregoing, it will be understood that I employ no mechanical propellers for producing the necessary agitation and beating into the froth the large volumes of air, but that I depend upon the compressed air admitted through a porous body which has the function of splitting up the air into innumerable fine streams and distributing these fine streams over and into substantially the entire surface of the pulp, whereby immediately upon the introduction of the air a more or less violent agitation or ebullition takes place and a froth begins to generate and to finally rise and form on the surface of the pulp."

The character of the agitation above described is also clearly recognized in the claims of the Callow patent.

The combination of claim 1 of the first patent in suit contains the following elements: (1) Mixing powdered ore with water; (2) adding a small proportion of an oily liquid having a preferential affinity for metalliferous matter (amounting to a fraction of one per cent on the ore); (3) agitating the mixture until the oil-coated mineral matter forms into a froth; and (4) separating the froth from the remainder by flotation.

The elements in the combination of claim 12 are (1) separating the mineral from gangue by coating the mineral with oil in water containing a fraction of one per cent of oil on the ore; (2) agitating the mixture to cause the oil-coated mineral to form a froth; and (3) separating the froth from the remainder of the mixture.

The elements entering into the defendant's infringing process are the same as those of claims 1 and 12 of the first patent in suit. There is no escape, I think, from the conclusion, not only that the defendant infringed the first patent in suit by carrying on the process of ore concentration in its first installation at Miami in apparatus in imitation of the plaintiff's standard machine, but also has infringed and is infringing the same patent by carrying on the process of ore concentration in its pneumatic flotation plant at the same place.

Validity and Infringement of Second Patent

The second patent in suit, No. 962,678, of June 28, 1910, to Sulman, Greenway and Higgins, is for "improvements in ore concentration." The patentees state that the object of the invention is "to separate certain constituents of an ore such as metallic sulfides from other constituents such as gangue when the ore is suspended in a liquid such as water." This patent is distinguishable from the first patent in suit; the object of the invention of that patent being, as stated, "to separate metalliferous matter, graphite, and the like from gangue by means of oils, fatty acids, or other sub-

stances which have a preferential affinity for metalliferous matter over gangue."

It appears from the patent as a whole that "other substances which have a preferential affinity for metalliferous matter over gangue" are restricted to those of an oily nature. Such substances as mentioned in the various claims of the patent are "an oily liquid," "an oily substance," "oleic acid," "oleic soap solution" and "oil." No other frothing agent than the above substances enters into the process of the patent. The essence of the invention of the first patent in suit was the restriction of the "oily substance" to "a fraction of one per cent on the ore." In the process of the second patent in suit no oil, fatty acid, or oily substances is introduced into the mixture. . . . [Quotations from patent.]

It will be observed that no one of the claims of the second patent in suit required as an element an oily substance or liquid, as is essential in the process of the first patent in suit, and all of the claims relied on require the introduction into the mixture of "a small quantity" of a "mineral frothing agent" or an "organic mineral frothing agent." The amount of the mineral frothing agent employed in the process is not confined to a fraction of 1 per cent on the ore, but must be a small quantity, evidently to be determined by the metallurgical engineer conducting or superintending the operation according to the requirements of the different ores.

The novelty of this invention is to be found, not in any restriction of the amount of the mineral frothing agent to any stated proportion, for there is none, but in the fact that a mineral frothing agent as the means of separating the metallic particles from the gangue is substituted for the oil, fatty acid or other oily substance essential to the process of the first patent in suit. Such substitution has produced successful results, and, I think, involved invention.

Frothing agents had theretofore been used in ore concentration, but not in the absence of an oily ingredient. Even were the grounds on which the validity of the patent can be sustained less clear, it should have the benefit of the presumption of validity arising from the grant of letters. That the defendant has infringed the claims in suit of the second patent is established by the evidence.

Invalidity of Third Patent and Conclusion

The third patent in suit No. 1,099,699 of June 9, 1914, to H. H. Greenway, assignor to plaintiff, is for "Improvements in the concentration of ores." In the description it is stated:

"This invention relates to the concentration of ores and has been applied in practice to the concentration of copper ores, the object being to separate certain constituents of the ore, such as copper sulfides (for example, in the form of copper pyrites) or metallic copper (natural or reduced), from other constituents such as gangue when the ore is suspended in a liquid such as water. The present process is a modification of the invention described in U. S. Patent to H. H. Sulman, A. H. Higgins and myself, No. 962,678, granted June 28, 1910. The process therein described is applicable generally to the recovery of metallic sulfides and like sulfides to which the process has been largely applied it is necessary for efficient working that the pulp should be slightly acidified, and in most cases in practice the pulp is heated. It is now found that with copper ore such as an ore containing copper pyrites the powderful ore with water containing in solution a minute quantity of aromatic hydroxyl compound such as phenol or cresol but without mineral acid and in the cold, agitating the mixture to form a froth and separating the froth."

The first twelve claims of the patent are in suit, but it is unnecessary to set them forth in full. I do not find any element of patentability in the process of this patent. It is stated in the description that the process can be carried on "without mineral acid and in the cold," and "is carried out in the cold and no acid is added to the pulp."

Under the second patent in suit the use of heat is optional, and no patentability can be attributed to the process of the third patent in suit on the ground that the process is carried on in the cold or without heat; for patentability can never result from the mere omission to do something, the doing or not doing of which is optional.

There is a question on which a difference of opinion has been expressed, whether in the process of the second patent in suit the use of acid is also optional. The description in the patent considered alone required the use of acid; but while five of the nine claims mention "acidified water," the remaining four do not refer to acid. It is not altogether clear to me under these circumstances whether the use of acid is not optional. But however that may be, I think that, in view of the processes of the prior art an omission to use acid in the process of the third patent in suit cannot confer patentability upon it.

Many actual or supposed inconsistencies or contradictions in the testimony have been commented on by counsel, but, while they have been considered, I do not deem it necessary to a proper decision of this case that they should be discussed in this opinion.

A decree in accordance with this opinion may be prepared and submitted.

Electric Furnace Steels

A conference on the above subject which brought out considerable interesting discussion was held during the week of the Exposition of Chemical Industries in New York under the auspices of the American Chemical Society. Dr. JOHN A. MATHEWS, president of the Halcumb Steel Co., presided.

Dr. Mathews compared the ancient and modern methods of iron and steel manufacture, emphasizing his remarks with a series of lantern slides. He pointed out that the modern process differed very little from that of the sixteenth century, the development of the industry having been almost entirely in machinery for handling the metal. The electric furnace is the most modern type of machine for the production of various kinds of steel and is being operated with considerable success by many manufacturers. Reproductions were shown of several types of electric furnaces, including the Heroult, Rennerfelt, Snyder, Roechling-Rodenhauser, Grönwall-Dixon, and others. A view of the first Heroult furnace installed in the United States at the Halcumb Steel Co.'s plant was also shown. This furnace is still operating and is the only single-phase Heroult now in operation in the country. In reply to a question from Professor Howe whether for certain purposes crucible steel is still decidedly better than electric steel, because the crucible steel is not heated to such a high temperature, Dr. Mathews said that the conditions are such that the electrically melted metal in the ladle, ready to pour, is not materially different from well-melted crucible steel. The principal difference, as Professor Richards has pointed out, is that the crucible steel is made in small ingots, which is somewhat of an advantage.

Dr. Mathews said that crucible furnaces are primarily not suited for making alloy steels. In the electric furnace the cost is lower, the necessary additions can be made in the furnace itself, and heating can be continued as long as desired without any material loss. The advantages of the electric method in making high-speed steel are not as marked as in the cheaper alloys.

In discussing the subject of working on cold and hot charges Mr. Humbert said that practically all the smaller furnaces use cold charges, the larger furnaces, such as of 15 and 20-ton capacity, operating on molten metal.

Professor Richards said that in a Norwegian plant steel ships are broken up and melted in an open-hearth furnace and the charge then transferred to the electric furnace. Even with electricity at \$6.40 per horsepower year, they found it cheaper to use a combination process and operate the open-hearth with coal at \$6 a ton. In discussing the stated superiority of ordinary carbon steel made in the electric furnace over that made in the open-hearth furnace, Professor Richards thought the dead-melt and the deoxidation possible in the reducing atmosphere of the electric furnace were important factors. There is also an opportunity in the electric furnace for the slag inclusions in the steel to separate out. Crucible steel and electric furnace steel are alike in that they are freer from foreign materials than either the open-hearth or Bessemer.

Dr. Mathews read a letter from K. W. Zimmerschied, metallurgist of the General Motors Co., Detroit, Mich., in which it was stated that it was the writer's experience that electric furnace steels are generally freer

from non-metallic inclusions than open-hearth or Bessemer, that they seem to have a considerably wider forging range, and also seem to have a wider hardening range, i.e., could be reheated to higher temperatures without becoming coarser grained than open-hearth or Bessemer steels.

Professor Richards thought the most efficient and satisfactory process for manufacturing alloy steels would in the future prove to be a combination of the Bessemer, open-hearth, and electric furnace, the steel being treated in each in the order mentioned. This is known as the triplex system. It developed later that the U. S. Steel Corporation has already installed a fifteen-ton triplex system at Joliet, Ill., and has under construction two other units of the same type, having a capacity of twenty tons each. Dr. Richards thought the question of refractories demanded considerable attention and asked whether zirconium oxide was being used in any way.

The question of power costs for electric furnaces took up considerable time. Mr. Morgan Smith of the Detroit Edison Company said that it was the ambition of the company to produce electric power with steam plants at such a low cost that it could not only compete with water power current but could undersell it. He intimated that the time would not be far in the future when this ambition would be realized. Professor Richards thought the power question was a secondary one with most electric furnaces except when making plain low-carbon steel to compete with open-hearth. Mr. Berry said the power companies did not fully appreciate the value of the electric furnace industry to them. Mr. Crosby said the central stations have been investigating the question more fully during the last three years.

In discussing uranium steel Mr. Hoffman said that it made very good tools, but that they did not seem to hold their efficiency. Two-tenths of uranium is supposed to take the place of 12 per cent tungsten. Dr. C. M. Johnson said from a few experiments he had made with low-carbon steels containing 0.3 per cent uranium, it did not seem that the material promised to be of any value, but that there might be other combinations which made a good high speed steel.

Milling of Ores.—The Hardinge Conical Mill Co., New York City, has issued an attractive little book on the uses of Hardinge mills in the milling of ores.

The Asbestos Protected Metal Company announces that Mr. William H. Cummings, formerly of Providence, R. I., has become associated with its Waugh glazing department.

A Large-Capacity High-Voltage Transformer.—Some interesting insulating tests were recently carried out at the University of Minnesota in conjunction with the Minneapolis General Electric Co., by means of a new high-voltage transformer, capable of giving a secondary voltage of 300,000 volts. The tests were made on insulators to be used on the Minneapolis General Electric Company's new 100,000-volt line from Chippewa Falls. The tests, which were conducted by Prof. W. H. Springer, were accompanied by a brilliant display of fireworks and a strong smell of ozone. A continuous heavy spark more than 3 ft. long was maintained in one test for several minutes. The insulators tested consisted of corrugated glass disks mounted on a rod of special insulating material. The transformer was built by the C. H. Thordardson Company of Chicago, and took two years to construct. It is submerged in 14 barrels of insulating oil in a steel tank, which is 7 ft. long, 5 ft. wide and 7 ft. high, with two terminals protruding 3 ft. from the top. The weight when full of oil is a little more than 5 tons.

Specifications for Single and Multiple Effect Evaporators *

By Otto Mantius

There is practically no literature which will give reliable information about evaporators so that chemists and engineers who have to purchase such an equipment can form their own opinion on the subject. According to my knowledge, and I have searched carefully the English, German and French technical literature, there are no books giving such information. Hausbrand only gives the physical laws and formulas, but no practical data for the construction of evaporators. Forster's book has only a collection of patents. Therefore the prospective buyer must entirely rely on the information contained in the catalogs published by the manufacturers of evaporators, and it is hardly possible to make up specifications from this information unless the purchaser is thoroughly familiar with all evaporating problems.

The object of this paper is to give some of the most important points which should be determined and considered when purchasing evaporating equipments.

QUANTITY AND NATURE OF SOLUTIONS

Unless the liquid to be treated is well known, and has been handled in evaporators before, it is absolutely necessary for the purchaser to give complete information to the manufacturer about the nature of the liquor. He should state the amount of liquor to be handled, the temperature and specific gravity of the feed liquor, and the density of the final product. If the solutions are of complex nature, it is best to give a complete analysis. If salts are to be separated from the solution, the quantity of this salt should be given. If possible, a sample of the liquid should be sent to the manufacturer, so that it can be tested in their experimental station.

It should be stated if the evaporator is to work eight, twelve, or twenty-four hours per day, and six or seven days per week. In case the equipment is to be operated continuously, an extra pan should be provided for, so that repairs can be made without shutting down the whole plant. Besides, the evaporator must be able to handle seven days' work in six days, and the purchaser should provide twenty-four hours storage capacity for both weak and heavy liquor.

NUMBER OF EFFECTS

If the evaporator is to be operated with exhaust steam entirely, the number of effects will depend on the quantity of steam available. I have known a case where quite expensive triple-effect evaporator was installed, and it was found afterwards that sufficient exhaust steam was available to do the work in a single-effect evaporator, which naturally would have been very much cheaper. If live steam is to be used entirely, the number of effects should be found by comparing the saving effected by one or two extra pans, as compared with the interest, depreciation and repairs required for this additional machinery.

The number of effects is sometimes limited by the boiling point of the liquor when it is concentrated to high density. It should also not be forgotten that in some cases the higher temperature which is absolutely necessary in multiple effects, will injure the liquor, which is especially the case with milk, malt extract, and others.

MATERIAL OF CONSTRUCTION

Evaporator bodies are generally built of cast iron, steel, or copper, and the tubes of cast iron, steel, char-

coal-iron, copper, brass, or aluminium. This point should be considered very carefully as the material of construction will greatly influence the first cost of the equipment. Up to a few years ago, it was impossible to sell a cast iron machine for concentrating milk, or malt extract. Everybody used copper. At present, practically all evaporators handling these liquids are built of cast iron. The material of construction should be such that it will not be attacked by the liquor, but at the same time it should be of such nature that it will not spoil the product by forming mineral salts which will discolor the liquid. With the present prices of copper, it would be cheaper in some cases to use steel or wrought iron tubes, and replace them with copper as soon as it has reached the normal price again.

Lead-lined and copper-lined evaporators have not been satisfactory, but I understand that some machines, built of solid lead, have given good service. A few evaporators have been lined with acid-proof brick in order to prevent corrosion by organic acids, and the lining seems to have stood up quite well.

TYPE OF EVAPORATOR

As a general rule, horizontal tube evaporators with steam inside, and liquid outside the tubes are used for all solutions which do not precipitate solids during the boiling process. Vertical tube machines with the liquid inside, and steam around the tubes will handle solutions which are concentrated to a point where only crystals remain, or liquors which separate salts during the boiling process.

There are at present made in this country about a dozen different types of evaporators, and it is quite hard for the purchaser to select the type which is most suitable for his purpose. The most important point which should be considered in selecting the type and make of evaporator is the general efficiency with which the equipment will handle the liquid.

The efficiency of the evaporator will depend on the coal consumption, and the loss of liquor caused by entrainment and foaming.

The amount of steam used to evaporate a certain quantity of liquor will depend entirely on the number of effects, and has very little to do with the type of evaporator. One pound of steam will always produce in a single effect 1 lb. of vapor, less the loss by radiation, and loss by the reduced latent heat of the steam at low pressure. The loss by radiation can practically be eliminated by good covering of all parts of the equipment, and will be practically the same with all types of evaporators. The steam consumption of multiple effects will go down in proportion to the number of effects used. The quadruple effect will always produce with 1 lb. of steam, 4 lb. of vapor, less the losses given above, provided the temperature of the feed liquor is the same in all cases. I wish to call attention to the fact that the total steam consumption is very much influenced by the temperature of the feed liquor, and certain arrangements can be made in multiple effect evaporation to reduce to a considerable extent the amount of steam necessary for the heating of this weak liquor.

The efficiency will also be influenced by the losses caused by entrainment and foaming or frothing. Losses by entrainment can practically be eliminated by proper construction of the evaporator. It is due entirely to the high vapor speed above the liquor level. An evaporator which has too small a square area above the heating surface will always entrain when the heating surface is working at its normal capacity. So-called entrainment separators and catchalls will save some of this loss, but it is naturally better to construct the pan right from the start in such a way that no liquor will be entrained.

*A paper presented at the New York meeting of the American Chemical Society.

The foaming or frothing is due to physical properties of the liquor, and losses can readily be avoided with almost any type of evaporator by careful operation.

The steam consumption and therefore efficiency of the equipment will be somewhat influenced by the arrangement of the outlets and valves which remove the non-condensable gases, and water of condensation from the steam. If the vent valves are kept open too wide, steam will escape from the steam chest to the vapor body, and become a total loss.

Further points to be considered are the method of operation, and the simplicity of construction. Pumps should be eliminated as much as possible, as their upkeep is very expensive. Sometimes a special type of evaporator is necessary in cases where only a limited amount of space is available. Delicate liquor, especially of organic nature, should not be subjected to the heat for any length of time, and it is therefore necessary to choose a type of evaporator which only contains a small amount of liquor.

RELIABILITY AND EXPERIENCE OF MANUFACTURER

The workmanship and material to be used in the construction of evaporating equipments should be of the very best quality. The efficiency and capacity of a multiple-effect evaporator will be greatly reduced by leaks from the outside or from the steam chest to the vapor space. When cast iron is the material of construction, only a very close grain iron should be used. In case the evaporators are made of steel plate, the most stringent specifications and rules for boiler work are just good enough for the construction of evaporators. Especially in caustic work, rivets and seams should be made up with the utmost care, as it is almost impossible to repair a seam after once the caustic has gotten between the plates or into the rivet holes. It is therefore absolutely necessary that the manufacturer should be reliable, and have long experience in the manufacture of such equipments. It is desirable that the builder should have his own factory, or at least be able to control the construction of the machinery.

ACCESSORIES

The condensers, receivers, salt filters, pre-heaters, and all pumps should be amply large and of the very best quality, especially where twenty-four hours' service is contemplated. Pumps should not be operated normally with more than twenty strokes per minute, and wherever possible, arrangements should be made to seal the stuffing box of the piston rod.

GUARANTEE

Unless the purchaser has had considerable experience with the type of evaporator, and the liquor, it is always desirable to ask the manufacturer for certain guarantees covering:

Quantity of liquor to be handled per hour or twenty-four hours.

Quality of the finished product.

Total steam consumption, including pre-heating of the feed liquor.

Quantity of cooling water to be used for the condenser.

Such a guarantee will generally increase the price of the equipment, but it is an excellent safeguard against comebacks. These tests can be made at very little expense. In addition to this guarantee for capacity and efficiency, the manufacturer should give a complete guarantee for workmanship and material.

PRICE AND DELIVERY

Without any question, the price of the equipment is of great importance, but it should only be considered

after all other points have been settled entirely satisfactorily. Quite frequently, a cheaper equipment will be very expensive to operate on account of the frequent repairs and replacements. The manufacturer should have a reasonable time for delivery, as evaporators are not carried in stock.

New York City

Observations Upon the Atmospheric Corrosion of Commercial Sheet Iron*

Particularly in Regard to the Influence of Copper and Mill Scale

By E. A. Richardson and L. T. Richardson

The corrosion of iron and steel is a question that is becoming of increasingly great importance. The problem of finding the true nature of and the ultimate causes that underlie the rusting of iron is as yet unsolved. Much work has been done in the past, is being done at present and before the problem is solved, much more will undoubtedly be done in the future.

The paper will not burden itself with a lengthy review of previous work that has been done upon the subject, but will confine itself to a brief summary of such work.

As regards the relative merits of wrought iron and steel much work has been done, but observations on the two materials seem to be in poor agreement.

Of recent years the question of the rust-resisting properties of copper-bearing steels has arisen and remains as yet unsettled, the chief contenders being the makers of copper-bearing steel and those of pure iron. As far as numerical data are concerned, the advocates of copper-bearing steel seem to be in the lead; in fact it seems to the writers that one weakness in the argument of the pure iron advocates is that they give little numerical data to support their claims. To many, their arguments would carry much more weight if such data were included.

Briefly, up to about 1910, a considerable amount of work had been done upon the subject of copper in steel, but this work was mainly in the form of fragmentary observations on steels that contained small quantities of copper either accidentally or intentionally added, and a few actual tests upon copper-bearing material. Previous to this time there appeared to be no acute controversy as to the effect of copper in steel upon corrosion, although judging from the literature it did exist at this time to a rather mild extent as to the effect of this metal upon the physical properties of steel. The general impression, one would gain from reading these articles, is that copper in steel is a benefit as regards resistance to corrosion.

Shortly after 1910 copper-bearing steel was put upon the market as a corrosion-resisting material. The controversy then became acute, the chief objectors being the advocates of pure iron. The result has been that a considerable amount of work has been done and published without settling the question. Most of this work seems to have been done by those interested in copper-bearing steel in their efforts to prove that this material is the real rust-resisting material they claim it to be. A large share of the published work, which contains results from tests closely approaching actual service conditions, has been done by Mr. D. M. Buck—a strong advocate of copper-bearing steel. The opposing side appears mostly in discussion of these and other

*A paper read at the New York meeting of the American Electrochemical Society.

¹Buck, D. M. "Copper in Steel. The Influence on Corrosion," *Jour. of Ind. and Eng. Chem.*, June, 1913.

²Buck, D. M. and Handy, J. G. "Research on the Corrosion Resistance of Copper Steel," *Jour. Ind. and Eng. Chem.*, March, 1916.

papers and appears to be taking a defensive stand. The impression, gained by the writers, from reading the available published evidence, is that copper-bearing steels do possess rust-resisting properties and are superior to any iron or steel now on the market.

Likewise, the influence of mill-scale upon the corrosion of iron is under discussion.

Friend³ for instance states that "traces of oxides upon the surface of metals are powerful stimulators of corrosion."

A. Sang⁴ says, "Black oxide only protects provided it is continuous and firmly anchored to the iron (Bower-Barffing, etc.); as mill-scale, which is loose and fissured, it is detrimental, the iron in contact with it and exposed rusts about 50 per cent faster."

Aston and Burgess⁵ find "that mill-scale had an accelerating effect for an atmospheric test and a retarding action for a fume test." Further they state that "there is no doubt that the protective property of mill-scale is dependent upon its physical properties, continuity, etc."

G. C. Whipple and M. C. Whipple⁶ tested steel, ingot iron and wrought iron with mill-scale and with mill-scale removed and obtained erratic results, but, generally speaking, the rusting was slightly greater in the case of the metals from which the mill-scale had been removed than in the case of the metals on which the mill-scale had been left. They state, however, "that the best remedy to protect steel from pitting is to remove mill-scale."

Buck and Handy⁷ in their latest paper state "at the time of exposure of the full-sized corrugated sheets careful notes were taken concerning the physical appearance of the sheets as affected by the amount of mill-scale which was present, and as to whether they were outside or inside in the pack. During the progress of the test this feature was carefully watched, and the time of ultimate failure of sheets whose surfaces were comparatively free from mill-scale was compared with others of the same grade, whose surfaces were well covered with mill-scale. From these observations, we concluded that the influence of this original surface oxide is slight, and is lost in the early stages of rusting, for no difference in final failure could be noticed."

One thing, however, in regard to many tests that have been made upon the relative corrosion of iron and steel, is that insofar as the ultimate consumer is concerned, they are not of the greatest value, since many times only two or three materials were compared, or the materials were made especially for test and cannot be obtained in commercial quantities. Such tests do not carry the most weight since they do not have the air of disinterestedness that exists in the case of materials purchased upon the open market. In fact one of the arguments of the pure iron advocates is the objection to "special tests" and the demand for basing comparisons upon service tests only.

In view of the fact that no results had been published of a complete test on commercial materials, it was deemed desirable to make a test containing all the types of iron and steel that could be obtained.

Some of the kinds of materials that are commonly used for structures, exposed to atmospheric corrosion, are:

1. Steel.
2. Puddled Iron.

3. Commercially Pure Iron.
4. Copper-Bearing Steel.
5. Cast Iron.

This paper deals with the first four classes.

Accordingly there were obtained upon the open market the following materials in the form of black sheets of 26 gage:

1. Bessemer Steel.
2. Open Hearth Steel.
3. Charcoal Iron.
4. Commercially Pure Iron.
5. Commercially Pure Iron.
6. Copper-Bearing Iron.
7. Copper-Bearing Steel.
8. Copper-Bearing Bessemer Steel.
9. Copper-Bearing Open-Hearth Steel.

These materials analyzed as follows:

	Copper	Manganese	Carbon	Phosphorus	Sulphur	Silicon
1	Trace	0.300	0.01	0.087	0.054	0.020
2	Trace	0.413	0.01	0.079	0.041	
3	0.044	0.031	0.01	0.050	0.024	
4	0.016	0.028	0.01	0.009	0.025	
5	0.028	0.009	0.01	0.006	0.024	
6	0.237	0.006	0.01	0.004	0.054	
7	0.181	0.100	0.01	0.003	0.077	
8	0.256	0.315	0.08	0.092	0.046	
9	0.268	0.387	0.01	0.052	0.024	

Before starting a work of this character, which involved quite some labor, due consideration was given to the methods of testing and in particular to those methods about which there is some difference of opinion. Questions arose concerning the desirability of a previous heat treatment and the necessity and means of removing mill-scale previous to testing.

Opinions differ as to whether samples of iron should be tested just as received or whether all test-pieces should receive some treatment so that the physical properties will be as nearly identical as possible. One author contends that samples should be tested as purchased, since the material that the samples represent will be used just as purchased. On the other hand, there are those who contend that all samples tested should have as nearly the same treatment as possible, in order to eliminate as many of the variables as possible. They suggest, therefore, that the test-pieces be annealed at the same temperature and that mill-scale be removed.

It would seem that the method used for testing should depend upon the results to which the data is to be put. If the results are intended for the ultimate consumer the material should be tested just as purchased since this is the condition that it is used by the ultimate consumer. On the other hand, if the data is for scientific purposes such as determining the effects of various elements in the material, all variables other than the ones under investigation should be removed if it is possible to do so.

However, to make the work as broad and as complete as possible, it was decided not to limit the test to one method, but to try out both ways and to determine the relationship between the two.

Since part of the specimens were to have the mill scale removed, the question arose as to what method should be used for removing this scale. In previous published work, very little has been said about the method of cleaning test specimens. When stated, however, it has usually been done by mechanical means such as filing or grinding, or by chemical means such as acids. Experiments were, therefore, conducted on the effects of methods of removing mill-scale upon the sub-

³ Friend, J. N. The Corrosion of Iron and Steel, p. 251.

⁴ Sang, A. The Corrosion of Iron and Steel, p. 81.

⁵ Aston, James, and Burgess, C. F. The Rate of Rusting of Iron and Steel. Eighth Int. Congress of Applied Chem., 26, 453.

⁶ Whipple, G. C., and Whipple, M. C. Mill-Scale as a Cause of Corrosion. Eighth Int. Congress of Applied Chem.

⁷ Buck, D. M., and Handy, J. O. Research on the Corrosion Resistance of Copper Steel. Jour. Ind. and Eng. Chem., March, 1916.

sequent corrosion. The results of these experiments have already been published.⁷ It was shown in this paper that methods of cleaning by the use of chemicals had a profound effect upon the rate of corrosion, especially on tests of short duration.

In the contemplated test a clean iron surface was necessary in which the surface iron was in the same physical and chemical state as the iron beneath the surface. It was, therefore, decided that removal of the mill scale by pickling in sulphuric acid, thorough washing with water and drying and subsequent removal of the surface iron with fine emery cloth would give a surface that was identical with the material itself.

The question also arose as to the method by which corrosion was to be estimated. There is a choice of methods to determine the rate of corrosion. One method commonly used is to determine the loss in weight after exposure for a given length of time and considering this loss as an index of corrosion. Another method is to allow the test specimens to corrode until failure occurs and to take the length of time as an index of corrosion. Inasmuch as there is some question as to the reliability of the "loss in weight" method, it was thought best to continue the test to the failure of the specimens.

This made it necessary to decide upon some standard condition at which failure could be considered to have taken place. Evidently, failure should not be taken at a point when the iron has completely rusted away or even when it has almost disintegrated, since any sheet iron in service would be of no value long before such a condition obtained. The point of failure selected was when the sheet iron was in such a condition that it could be seen to be perforated when the rust was removed by gentle tapping with a blunt object such as a file or nail. By using one specimen of each kind of material as a test piece that was tapped and examined at intervals of about two weeks, a close approximation to the time of failure could be obtained. Thus the other specimens were not molested until the latter part of their useful life and the effects of tapping were practically eliminated from the results. By this method, it is believed that the life of each material was obtained to within an error of three or four weeks.

The sheets of 26-gage iron were accordingly prepared for test by cutting into pieces 5 in. x 8 in. (12.7 cm. x 20.3 cm.). For the test on the material as received ten pieces of each kind of iron, that were found by measurement to be of standard thickness, were used. For the test on the prepared material, a number of pieces of each material were annealed at a red heat and then cleaned by the method already described. Great care was taken to give all of these test pieces exactly the same treatment. Ten of the prepared specimens of each material that were found by measurement to be of the same thickness were taken for test. These prepared pieces were of practically the same thickness as the "as received" samples tested, due, no doubt, to the extreme thinness of the mill-scale.

On account of the precautions taken as regards uniform thickness of materials, the method of estimating failure and the method of cleaning surface, it is believed that the tests should be comparative.

All samples were then placed securely in a wooden rack and exposed to the weather May 24, 1914. The atmosphere was what might be described as a semi-country one, and cannot be taken as an atmospheric acid test.

At the very start a marked difference was noted in

the character of the rust formed on different materials. Whereas, on the Bessemer and open-hearth steel samples, the rust was of a yellowish-red color and became loose rapidly, the rust on the others was dark red in color and much more adherent. This adherent

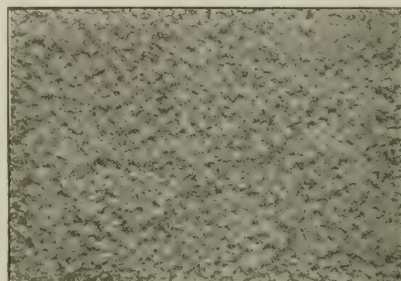


FIG. 1—RUST ON BESSEMER AND OPEN-HEARTH STEEL

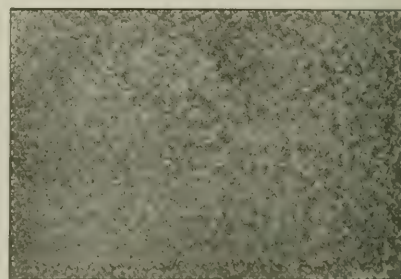


FIG. 2—RUST ON CHARCOAL IRON

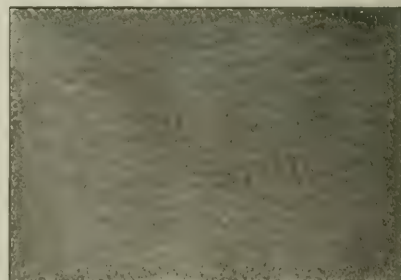


FIG. 3—RUST ON COPPER-BEARING STEEL

state seemed to reach its maximum in the copper steels, where the rust was very dark and fine grained. Fig. 1, Fig. 2 and Fig. 3 represent photographs taken about one year after the test was started and conveys in a rather poor way the character of the rust. Fig. 1 is characteristic of Bessemer and open-hearth steel. Fig. 2 is characteristic of charcoal iron, of commercially pure iron and iron containing copper, and Fig. 3 is characteristic of copper-bearing steels.

From visual observations at this time there appeared to be little difference between pure irons with or without additions of copper.

The life of the different materials tested is given below; each figure being an average of ten test pieces and represents the time for failure in days:

⁷ Richardson, E. A. The Effect of Pickling on the Corrosion of Iron. *Mett. and Chem. Engng.* 12, 759.

At the present writing the three samples of copper-bearing steel are still in good condition. The rust is still adherent and the underlying metal is still intact. The life of these steels has been estimated at 1200 days, which figure the writers believe is very conservative. These specimens are still exposed to the weather and will be until failure occurs.

Material as Received		Material Annealed and Surface Cleaned	
1.....	348	363	
2.....	367	361	
3.....	615	538	
4.....	508	437	
5.....	675	467	
6.....	743	601	
7.....		1200 (estimated)	
8.....	1200 (estimated)		
9.....			

Conclusions. Taken as a whole, the results indicate that copper-bearing steels are, without doubt, decidedly superior to any of the other materials tested. The remaining materials may be divided roughly into two classes, one class including the ordinary steels (Bessemer and open-hearth) and the other class, the commercially pure irons and the copper-bearing irons. Charcoal iron is classed with the pure irons. We have obtained results in another test which would indicate that the resistance of wrought iron to corrosion is due to the purity of its iron and not to slag inclusions. In addition, it was noted during the present test that charcoal iron appeared to corrode in very much the same way as pure iron.

In regard to the steel-iron question it is noted that the pure irons (including charcoal iron) are superior to steel. It is believed that this superiority is due to the purity of the iron, or to some combined effect of manganese and copper.

The results obtained in regard to the effects of mill-scale do not agree with the results obtained by others. They indicate that with steels which rust rapidly, mill-scale is a stimulator of corrosion. On the other materials tested, the mill-scale has exerted a protective action. We have no explanation for this.

The important feature of the results, however, is that it substantiates the claim made in several other publications that the addition of copper to steel in amounts of about 0.25 per cent causes a remarkable increase in its ability to resist atmospheric corrosion. In the present test, the addition of about 0.25 per cent copper to Bessemer or open-hearth steel has resulted in an increased resistance of 300 or 400 per cent.

The addition of copper to pure iron also results in an increased resistance to corrosion, but to no such an extent as the addition of a similar amount to steel. The addition of about 0.25 per cent copper to a commercially pure iron results in the useful life being increased by about 20 per cent. This figure was arrived at by comparing the average life of irons Nos. 3, 4 and 5 with No. 6.

We have been unable to determine the reason for this effect of copper in reducing corrosion. It is believed, in view of the fact that the copper exerts a greater influence in steel than in iron, that it must be due to the combined presence of copper and manganese, since the chief difference in the iron and steels under consideration is in the manganese content. It may be that the copper eliminates a harmful effect of manganese, or it may be that it is some combined effect of these two elements that acts as a protection to iron. The writers are inclined to believe that it is the latter cause.

This conclusion, the writers believe, is also confirmed by the results of other observers. Mr. D. M. Buck* tested several kinds of sheet irons and steel by exposing

pieces 2 in. x 4 in. (5.08 cm. x 10.16 cm.), 27 gage, to the atmosphere in a mill yard at McKeesport, Pa., and found the loss in weight after eleven months to be as follows:

No.	C.	Mn.	S.	P.	Si.	Life	Loss*	Condition of Surface After 11 months
E	.04	.30	.043	.065		31	2.65	No holes.
V	.04	.39	.073	.114		31	2.75	No holes.
Z	.04	.43	.049	.099	.011	25	2.50	No holes.
D	.06	.50	.037	.016		26	2.94	No holes.
C	.05	.33	.035	.018		25	3.00	No holes.
H	.042	.16	.024	.005		21	3.65	Long time in 2 pieces.
O	.027	.07	.033	.007		09	3.31	Long time in 1 piece.
W	.049	.05	.015	.005		10	3.72	Many holes in all pieces.
J	.022	.03	.011	.006		.094	4.17	Many holes in all pieces.
I	.03	.06	.015	.002	.029	.07	4.25	Many holes in all pieces.
Y	.04	.45	.046	.099	.006	Trace	6.94	Only a lace mark of steel left.

*Loss given in oz. per sq. ft.

Similar results were obtained upon tests made at Scottdale, Pa., and in McKeesport city water. These tests indicate that copper even up to 0.10 per cent added to low manganese materials increases their resistance to corrosion but little. Ordinary steels containing about 0.40 per cent manganese, but no copper, are very poor as regards resistance to corrosion but additions of copper to such steels result in a greatly increased resistance. A maximum resistance is reached with about 0.25 per cent copper. These results were also confirmed upon full-sized sheets of the same materials and in the above cited papers several excellent photographs are given.

The writers believe, in view of these results, that the resistance of pure iron to corrosion could be increased by the addition of both manganese and copper, and that additions of manganese to pure iron or steel, even up to 3 or 4 per cent, or more, with a corresponding increase in copper to produce a maximum effect should give a material more resistant to atmospheric corrosion than the copper steel now on the market.

Also, some interesting results might be obtained by substituting for manganese in copper-bearing steels or irons, chromium, vanadium, tungsten, or molybdenum.

SUMMARY

1. Copper-bearing steels are decidedly superior to pure iron, steel, or charcoal iron.
2. The addition of copper to pure iron increases its resistance to corrosion, but to no such an extent as similar additions to steel.
3. Charcoal iron and pure iron are superior to steels as regards resistance to atmospheric corrosion.
4. Charcoal iron is very similar to pure iron in its resistance to corrosion.
5. Copper is believed to decrease corrosion due to some mutual influence of manganese and copper.
6. The additions of larger amounts of manganese and copper to pure iron or steel are suggested as well as additions of copper-chromium, copper-vanadium, copper-tungsten, or copper-molybdenum.
7. Mill-scale stimulates corrosion in rapidly rusting materials and retards it in slowly rusting materials.

*Buck, D. M. Recent Progress in Corrosion Resistance. Amer. Iron and Steel Inst., May, 1915.

Also pamphlet Keystone Copper-Bearing Steel. American Sheet & Tin Plate Company.

Foreign Trade.—At the third annual meeting of the National Foreign Trade Council held recently at the Hotel Biltmore, New York, it was the consensus of opinion that in order to meet the world's economic conditions following the war, combinations of exporters must be legalized, the tariff system must have greater elasticity, the merchant marine must be developed and special education must be provided.

High Temperature Heat Developed During Electrolysis*

By Carl Hering

When the current density on a cathode immersed in certain aqueous electrolytes, is increased sufficiently, the cathode becomes red hot and may even melt. Steel can thus be melted electrically while immersed in an aqueous solution.

The purpose of the present notes is to describe briefly some of the properties of this phenomenon and to give some quantitative data obtained from tests. These tests were made only for a preliminary study of these properties and the quantitative data are therefore only crudely approximate.

The explanation of the phenomenon is that with such high current densities the volume of gas formed around the cathode so diminishes the cross section of the conducting liquid between the bubbles that the so-called pinch effect severs what is left of the liquid conductor and keeps it severed by breaking it instantly wherever the liquid and electrode tend to unite again. The film of gas thus formed around the cathode either has an extremely high resistivity, such that the current passing through it develops much heat, or else something of the nature of an arc forms in this film, the difference being that in the latter case there is a transference of material through the current path, while in the former there is none; the indications are that the passage of the current through this film is of the nature of an arc. In some respects this film is like that formed in the so-called spheroidal state, when water is dropped on a red-hot plate.

The electrolyte must be one which will develop a free gas at the cathode at these high current densities, which almost any aqueous solution will do. The impressed voltage must of course be high enough to force the current through this film, from 65 to 115 volts in these tests.

The present tests were made with current from a lighting circuit of 123 volts using a bank of lamps in series with the cell. Small strips of thin sheet iron were used as cathodes; the anode was lead, and the solution sulphuric acid of about 1.2 specific gravity. The current through the cell, the voltage at its terminals, and the surface immersed (counting both sides) were measured. Owing to the meniscus and the violent ebullition this surface could be measured only approximately, and as it was small the error due to the three edges and two corners may have been relatively large, as in electrolysis the equivalent of an edge and a corner in terms of a surface, is an unknown factor.

When, with a limited current, a cathode is first immersed deeply so that the usual gasing in the cold state takes place, and is then gradually withdrawn to reduce the submerged surface, a point will be reached when a very sudden change takes place; the current will fall greatly, the voltage will rise greatly, there will be a hissing noise, and the cathode will instantly become red hot, at times melting into globules. The liquid surrounding it also looks red, having the delusive appearance of also being red hot.

If, while thus red hot, the electrode is lowered again very slowly, this high temperature state can be maintained for considerably greater immersions than that at which it started during withdrawal.

By then continuing to lower it, a state is reached without much change in the current or voltage (the current rises and the voltage falls), in which the cath-

ode ceases to be red hot but is enveloped in a distinctly blue film and the hissing is louder. With a still further immersion the conditions change very suddenly again to that of ordinary electrolysis, the current increasing and the voltage dropping, both very greatly. This change occurs when the film breaks and the surface is again wetted by the liquid.

Hence to produce this phenomenon, under the conditions of this test, the cathode must be immersed slowly, only as fast as it becomes heated; the moment the film becomes broken by the surface becoming wetted, the phenomenon ceases. With sufficiently high current densities it will break into this hot state immediately on the closing of the circuit, even when the cathode has previously been immersed.

As the cathodic gas is presumably hydrogen, it was thought that the iron cathode would remain clean and bright. Quite the contrary, however, a thick, black, brittle material forms on it in molten globules, which no doubt is the black oxide, as it is dissolved readily by the current when the film is broken and ordinary electrolysis takes place. The oxygen of this oxide seems to have come from the water, being presumably carried across the film by the arc. Unless this rapid formation of oxide can be prevented, the use of this method for tempering steel objects superficially by opening the circuit after the surface has been heated and while still submerged, would probably not be practicable.

The following data will give a rough idea of the quantitative relations. At about 10 amp. per square centimeter (9290 amp. per square foot) the sudden break from the cold state to the hot state tends to begin, at least under the conditions of this test. The energy at the surface of the cathode before the break, was then being developed at the rate of about 100 watts per square centimeter (93 kw. per square foot), much of which was chemical energy.

When the break occurred the current fell abruptly to about a fifth and the voltage rose more than tenfold. The current density therefore then becomes much smaller, but the surface energy becomes very much greater.

When the current density after the break is about 3.5 amp. per square centimeter (about 3250 amp. per square foot) the break always occurs, even when the circuit is closed after the cathode is immersed, hence it was not possible to measure it before the break occurred. The surface energy was then being developed at the rate of over 400 watts per square centimeter (about 370 kw. per square foot), which is presumably a far higher heating rate than is developed by a blast flame directed on to a surface.

The following figures will give some idea of what this high rate of heat development means. It is equal to 350 B.t.u., or 78.5 kg. calories, per second per square foot. If a kilowatt-hour will melt about 7 lb. of steel, this energy would melt about $\frac{3}{4}$ lb. of steel per second over a surface of 1 sq. ft., and it is likely that most of this film heat goes into the metal and less of it into the water on account of the very high surface resistance of water. The usual steam boiler practice of evaporating 3 lb. of water per hour per square foot of heating surface, is equivalent to a flow of energy through the walls of the tubes, of about 0.85 kw. per square foot; hence 370 kw. represent a rate of surface heating about 440 times as great as that in ordinary boiler practice.

During the next state when the cathode becomes cooler and is enclosed in a blue hissing envelope, the current density was about 4 amp. per square centimeter (about 3700 amp. per square foot) and the energy de-

*A paper read at the New York Meeting of the American Electrochemical Society.

velopment at the surface was about 270 watts per square centimeter (about 250 kw. per square foot) showing that the current density was then a little higher than during the red hot state, but the surface energy development was considerably less, hence the cathode was cooler.

When the current density during the latter state is then still further reduced by deeper immersion, to about 2 to 2.5 amp. per square centimeter (about 1900 to 2300 amp. per square foot) and the surface energy to about 130 watts per square centimeter (about 120 kw. per square foot) and the surface energy to about 130 watts per square centimeter (about 120 kw. per square foot), the film breaks, the cathode becomes wetted and ordinary gassing in the cold state sets in. Hence roughly about 100 kw. per square foot is the breaking point either way. Being caused by the pinch effect, current densities may not be the criterion in this phenomenon.

A rough test was then made in which the electrode to be heated was made the anode. Only by barely touching the liquid with the anode could any high temperature effects be produced, and even then only the corners became visibly red; with a further immersion the film always broke. The voltage before the break was about 117, very nearly the maximum available, and even this gave less than half an ampere; with a higher voltage better results could no doubt be obtained. The current density was, as nearly as could be estimated, about 4 amp. per square centimeter, hence about like that with the cathode, but the energy development was over 450 watts per square centimeter, hence higher than with the cathode. This may be due to the fact that only half as much gas is developed per ampere at the anode than at the cathode, or if an arc is formed through this film it may mean that the current traverses the arc more easily from liquid to electrode than from electrode to liquid.

The metal of this anode was eaten away slightly at the edge and was coated with a red layer, presumably the lower oxide, though sometimes it was left gray and bright. It did not seem to be dissolved however as fast as would be expected.

The curious fact that the cathode apparently becomes very strongly oxidized when thus heated, interferes with using this method for the surface hardening of steel objects; but with higher voltages it might be possible to heat so rapidly, perhaps in a few seconds, that the oxidation during that brief time might not be serious.

As this method enables one to heat a surface far more rapidly than it can be done by means of a flame, it may become possible to heat a surface to a high temperature so quickly that the heat would not penetrate into the interior until after the object of the heating has been accomplished, as for instance in alloying a surface with a metal which has been plated upon it. The heat is also more evenly distributed over a complicated surface than is possible with a flame, and the temperature is not limited like in combustion heat.

If it should be true that the passage of the current through this film forms a true arc, then it would seem to follow that the true electrolytic action takes place on the liquid side of the film, which would mean that the real cathode then is the film of hot gases and not the metal. The conditions would then be similar to when an arc is struck between a carbon rod and the upper surface of an electrolyte, in which the question also arises what the real electrode is at which the electrolysis takes place. Unipolar electrolysis would be contrary to our present conceptions.

¹Philadelphia, Pa.

History of the Flotation Process of Inspiration*

By Rudolf Gahl, Ph.D.

Metallurgist in Charge of Concentrator, Inspiration Company, Copper Co.

(Concluded from page 405)

Operation of Large Concentrator

FLOW SHEET OF CALLOW SECTIONS

The first four sections of the commercial concentrator of the Inspiration Company were equipped with Callow flotation machines. The flow sheet followed in these sections is illustrated in Fig. 19. As will be seen from this illustration, the ore, after having been reduced to the desired fineness, and having been oiled in the Marcy ball mills, is sent to twelve (in other sections eight) Callow cells. The tailings from these primary cells are sent to a drag classifier designed by

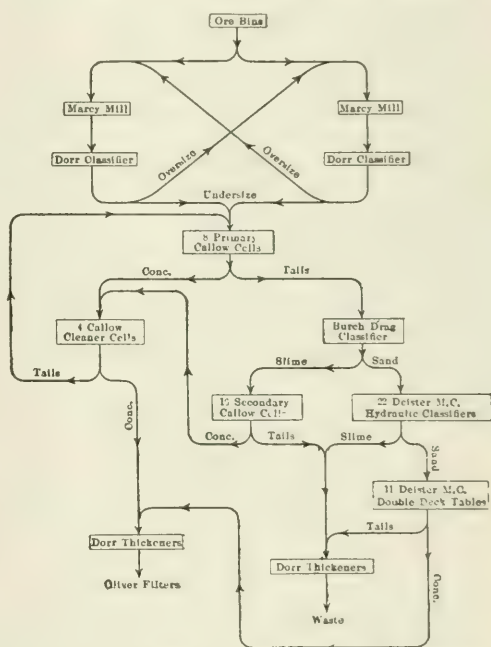


FIG. 19—FLOW SHEET OF INSPIRATION CONCENTRATOR SECTIONS EQUIPPED WITH CALLOW FLOTATION MACHINES

Mr. Burch, which effects a separation of sand and slime. The slime is retreated in twelve (in other sections sixteen) additional Callow cells, while the sand is sent to a hydraulic classifier and then to tables. The concentrates made both on the primary and the secondary Callow cells are retreated in a group of four Callow cleaning cells from which the tailings are returned to the head of the primary Callow cells. On the tables of the Deister Machine Company a separation is made between concentrates and tailings, but no middlings are produced and no part of them is re-ground. This, however, is probably only a temporary arrangement, the idea being that a suitable regrinding and reconcentration process will be installed later, after having been worked out by extensive tests.

FLOW SHEET OF INSPIRATION SECTIONS

Thirteen sections of the Inspiration concentrator are equipped with Inspiration flotation machines. The flow

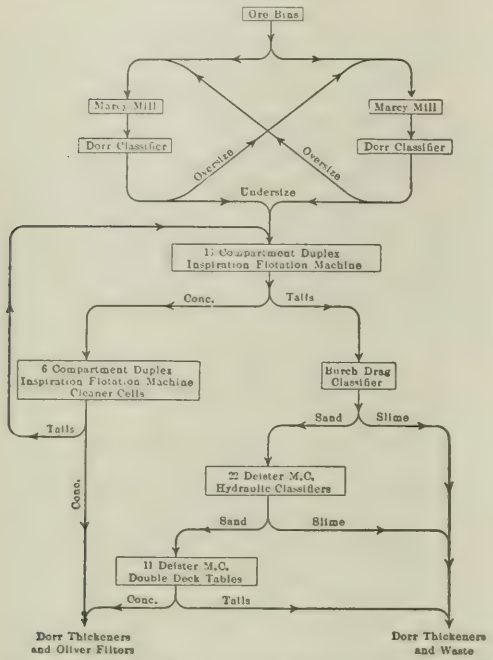


FIG. 20—FLOW SHEETS OF INSPIRATION CONCENTRATOR SECTIONS EQUIPPED WITH INSPIRATION FLOTATION MACHINES

sheet of these sections is represented in Fig. 20. The ore, after having been crushed and oiled, passes to the head of the flotation machines and traverses their whole length. The resulting tailings are split by the same kind of a drag as mentioned before, into a sand and slime product. The slime product is run to waste. This is thought permissible because, after having passed through the whole length of the flotation machine, the slime has been impoverished to such an extent that retreatment seems unnecessary. The sand product undergoes the same retreatment as that described for Callow sections.

INSPIRATION FLOTATION MACHINE OF STEEL CONSTRUCTION

Fig. 21 shows the drawing of an Inspiration flotation machine of steel construction as designed by Mr. Burch's office. At the end of each section of eight compartments, a pulp overflow is provided which regulates the level of the pulp in the preceding compartments of the flotation machine. The subdivision into two sections of eight is made in the interest of closer regulation of the pulp levels. It had been feared that if no such subdivisions were made, and the regulation of the levels accomplished at the tail end only, appreciable fluctuations might take place in the compartments near the feed end due to changes in the volume of pulp treated, and might prove highly undesirable.

One point in the construction of the Inspiration flotation machines in which we take considerable pride, is the method in which the air is introduced. The machines have solid bottoms; all pipe connections are made from above and are at all times visible. The porous bottom rests on top of the regular bottom of the machine and is introduced from above. It is illustrated in Fig. 22. As will be seen, it consists of a lower air chamber having partitions running lengthwise, which, however, do not extend down to the bottom of the air chamber and, for this reason, do not

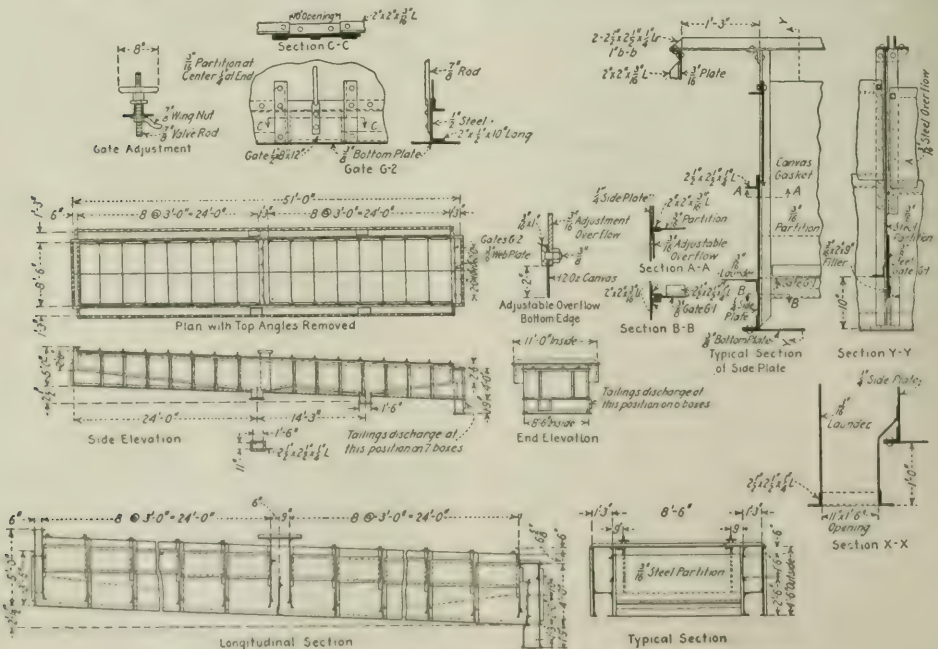


FIG. 21—INSPIRATION FLOTATION ROUGHER CELLS OF STEEL CONSTRUCTION

interfere with the interchange of air between the narrow compartments thus formed. A grate, which forms the upper part of the porous bottom can be fastened to the lower part by a number of bolts. Before putting them together, a porous medium (for instance, canvas) is placed between the two pieces. The air enters through a pipe from the top which screws into the lower casting. Arrangements are made, of course, to secure an air-tight joint where the pipe passes through the porous medium. When assembled, the bars of the upper grate form channels in the lengthwise direction of the machine. The bars are the only parts that protrude above the canvas and, on account of their arrangement longitudinally, they do not interfere with the passage of pulp through the machine.

The cleaner cells consist of six compartments in series. Both rougher and cleaner cells are divided by a partition in the middle, running the whole length of the machine. The operator is therefore enabled to throw all the feed on one side of the machine when desired, thus permitting repairs to be made on the compartments of the other side whenever necessary.

In the beginning it had been supposed that throwing all the feed on one side of the flotation machine might seriously overload that side, and for this reason, in the first sections installed, provisions were made to permit removing and replacing the porous bottom from any one compartment without interrupting the flow of pulp. As far as lifting out the bottom is concerned, this, of course, can be done in any case, but while one of the bottoms is withdrawn sand will pile up to a certain extent in the middle of the compartment. To remove this sand before returning the porous bottom, a system of perforated water pipes was installed under the air chamber. They allow the washing out of the bottom of the machine by the application of water pressure.

MINERALS SEPARATION SECTION

One section of the concentrator is equipped with machines of the Minerals Separation Company, Hebbard

type. The flow sheet, as illustrated in Fig. 23, is practically the same as the one shown in the Inspiration sections. The only difference is that two cleaner cells in parallel are used in place of the one cleaner cell of the Inspiration type. The drawings of the machine are reproduced in Fig. 9.

FILTER PLANT

It is necessary to reduce the ore to a certain fineness before the mineral contents of the feed can be treated by flotation, and as fine concentrates have the characteristic of retaining water with greater tenacity than coarse concentrates, a filter plant is a necessary adjunct of a flotation plant.

In the Inspiration mill both the flotation and table concentrates are sent to Dorr thickening tanks, five of them being 60 ft. in diameter and three of them 80 ft., representing a total area of about 29,217 sq. ft., or, as the daily production of concentrates amounts to about 600 tons, a settling area of around 48.7 sq. ft. per ton of concentrate sent to the settling tanks. The settling tanks are each provided with a double ring of high baffle boards to prevent the foam that forms on the top from contaminating the overflow. The settling used to be carried out in two steps, some of the tanks serving as preliminary settling tanks, while others resettled the overflow from the preliminary tanks. At present we operate all the concentrate settling tanks in parallel.

The spigot discharges feed six Oliver filters. The ratio of solids to water is about 1.65 to 1 at this point. The filters reduce the concentrate moisture to an average of about 17 per cent of the wet pulp. This figure varies, however, within rather wide limits from day to day. The moisture contents of the concentrate seem to depend in the first place on the percentage of insoluble material contained in the concentrates, as will be seen from the graphic representation of the relation between the two things in Fig. 24. It will be noted that a rise in the percentage of insoluble matter gen-

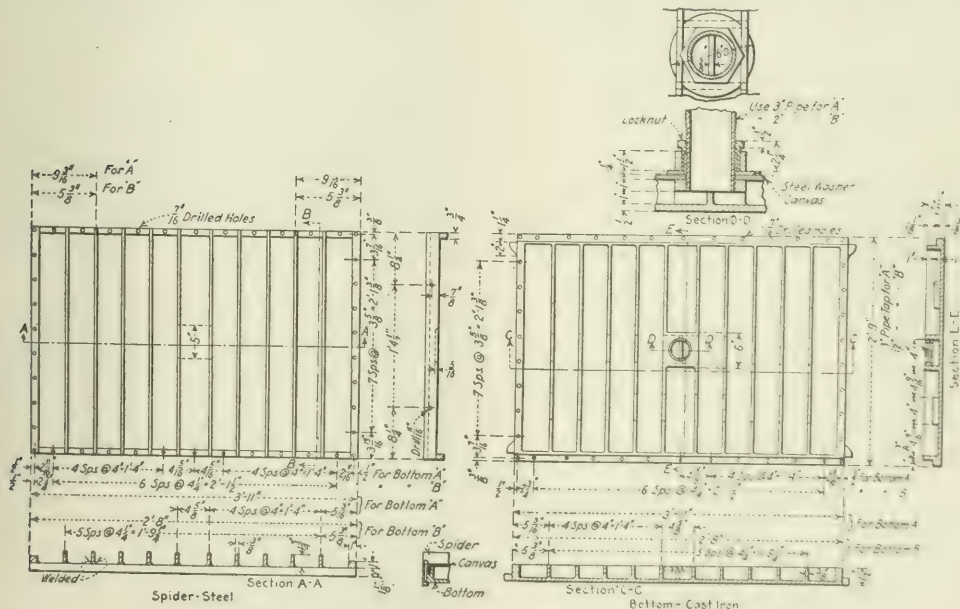


FIG. 22—INSPIRATION FLOTATION MACHINE BOTTOMS

erally corresponds to a rise in the concentrate moisture and *vice versa*. A moisture of 17 per cent is, of course, in excess of what seems desirable in view of the fact that the smelter penalizes water contained in the concentrates.

For this reason several attempts have been made to reduce the moisture. The first plan followed was to inject steam into the filter tank, with the object of heating the pulp. An appreciable increase in the capacity resulted from this, while no marked reduction of the moisture contents took place. The same effect was obtained by the addition of slaked lime, which we tried lately in our Oliver filters. It shows itself very readily in the formation of a thicker filter cake, thus causing a larger output of the filters. We have, however, not been able to effect a reduction in moisture by the use of lime. We have adopted the addition of lime to the filter pulp in regular operation on account of its decided benefit as far as the capacity is concerned. As a rule five filters can handle the whole output of the concentrator; that is, each 12 x 12-ft. Oliver filter has a capacity of about 120 tons in 24 hr.

Results Obtained in Commercial Concentrator

On account of the fact that the concentrator operated by the Inspiration company has only just left the stage of construction, it is not possible to give results obtained in the operation of it as a whole. As, however, an interval of several months has elapsed between the starting of the first and the 18th section, we are in a position to give at least preliminary results derived in actual operation on a fairly large scale.

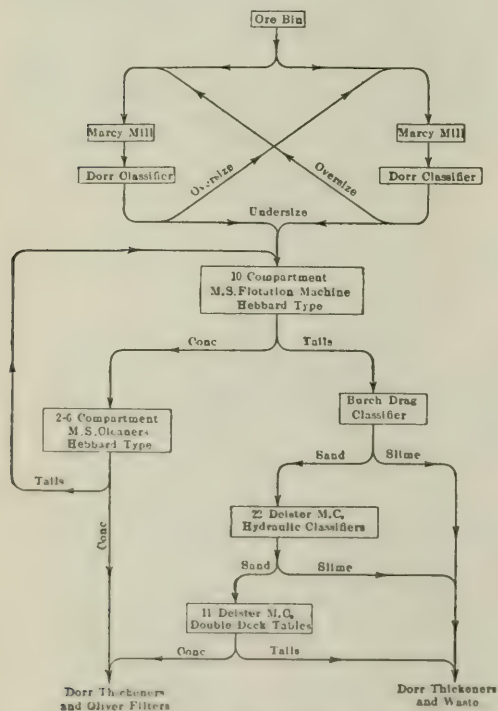


FIG. 23—FLOW SHEET OF INSPIRATION CONCENTRATOR SECTION EQUIPPED WITH MINERALS SEPARATION FLOTATION MACHINE.

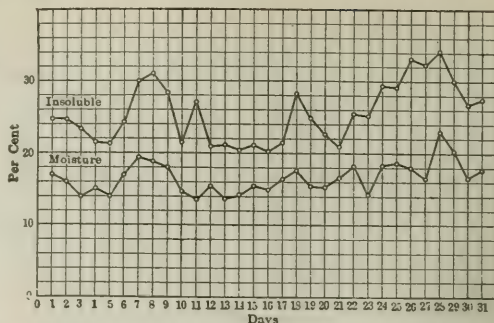


FIG. 24—CURVES SHOWING RELATION BETWEEN MOISTURE CONTENTS AND INSOLUBLE MATTER IN CONCENTRATES, OCTOBER, 1915

TONNAGE

Each of the sections of the Inspiration concentrator has a rated capacity of 800 tons; at present most of the sections exceed 900 tons actual capacity. Ordinarily, this tonnage is treated on one Standard duplex Inspiration machine consisting of sixteen double compartments, while the concentrates are cleaned on a cleaner cell with six double compartments. The size of the roughing compartments is 3 ft. by 4 ft. 3 in.; the size of the cleaner compartments is 3 ft. by 3 ft. Accordingly, the total area of combined rougher and cleaner cells is 492 sq. ft. Assuming the tonnage handled to be 800 tons, this makes a tonnage treated of 1.62 tons per day per square foot of surface. In the course of construction the erection of flotation machines did not always keep pace with the erection of the grinding mills. For this and other reasons it has frequently been necessary to combine the product from the two grinding sections in one flotation section; in other words, to throw an overload of 100 per cent on the flotation machines. Our experience is that overloading the machines by 100 per cent, or raising the tonnage to 3.24 tons per square foot of surface, does not increase the tailing losses very materially.

It follows, therefore, that the machines handle an overload without serious additional copper loss, and it has been our experience that there is no mechanical trouble whatever connected with overloading the flotation machines to such an extent. We have also had to resort to overloading the Callow cells, and have likewise found that the recovery does not fall off seriously.

For the Minerals Separation machine of the Hebbard type, which is installed in our section No. 10, we have no figures of a similar character.

AIR AND POWER CONSUMPTION

We have found that three blowers, of a capacity of 8000 cu. ft. per minute each, are sufficient to supply air for six sections of flotation machines. Accordingly, one section requires 4000 cu. ft. of air per minute. As the flotation machines in an Inspiration section have a surface of 492 sq. ft., it follows that the air consumption per square foot of porous surface is 11.8 cu. ft. per minute; the maximum pressure required is 4½ lb. at the blowers and practically the same at the flotation machines, as there is no serious loss of pressure in the air-conduits. The power consumed for furnishing air has been determined carefully by wattmeter readings of the motors furnishing power for the blowers. The actual power consumed is 87.5 kw. per section; or, figuring again with the rated section capacity of 800 tons, 2.63 kw.-hr. per ton of ore treated. We have not been able to make

separate tests for the Callow and Inspiration sections, but assume that the air consumption is approximately the same in both. We have no figures yet for the Hebbard type machine. To get the total amount of power consumed in connection with the flotation machines, a small amount of power, probably around 10 kw. or 0.30 kw.-hr. per ton of ore, has to be added to the power consumed for the production of air on account of the fact that the cleaner tailings are pumped back to the rougher cells and retreated, and that in the Callow sections the slime overflow of the drag classifiers is repumped to the secondary flotation cells. In the Inspiration sections, 0.425 sq. ft. of actual open porous surface and 0.615 sq. ft. of flotation machine area are provided for the treatment of one ton of ore in twenty-four hours.

FLOOR SPACE

The total floor space of the flotation floors amounts to 25,200 sq. ft., or 1.75 sq. ft. per ton of ore treated in twenty-four hours (rated capacity). The total floor space occupied by the concentrator proper (not including, however, the crushing plant located at the mine) is 81,900 sq. ft., or 5.68 sq. ft. per ton of ore, and the total floor space, if the settling-tank installation outside the main mill building is also included, is 258,890 sq. ft., or 17.4 sq. ft. per ton of ore (rated capacity).

WATER CONSUMPTION

The water added to the pulp where it reaches the flotation machines is about three tons of water for each ton of solid pulp. The subsequent treatment, in our case, requires a further addition of nearly three tons of water per ton of dry ore. However, as it is carried out on pulp that has been deprived of its slime contents by passing it over drag classifiers, the water thus entering the table tailings can be easily removed again. This is accomplished in our case by settling the table tailings separately from the slime tailings. The settling of the sand tailings is effected in a settling tank of home construction, consisting of a rectangular box with a sloping bottom into which a number of Caldecott cones are inserted. The resulting overflow is not quite clear, but is made so by resettling in three 60-ft. Dorr tanks.

Out of the total quantity of water actually added to the ore during its passage through the mill, amounting approximately to six tons of water per ton of ore treated, as mentioned above, nearly three tons, *i.e.*, the amount added during the table treatment can, as explained above, be reclaimed rather easily. For the reclamation of the rest of the water, settling ponds, of the well-known construction in which the reservoir is formed by building a retaining wall of sand across a gulch, are resorted to in addition to Dorr thickening tanks.

RECOVERY

The recovery obtainable by the application of our milling process is determined entirely by the composition of the ore, *i.e.*, by the relation between sulphide and oxide copper contained in the ore. Our average sulphide copper extraction has been 90.39 per cent for the months of March, April and May, 1916, the last months for which figures were available at the writing of this paper. A certain recovery of the oxide-copper minerals, especially carbonates, is made in the flotation process as well as in the gravity concentration process. The percentage of such mineral recovery is low, probably around 25 per cent. For this reason the recovery obtainable on ore containing a high amount of oxide, such as surface ore, is correspondingly lower. We have worked in the laboratory with the object in view of increasing the oxide recovery; for instance, by adding certain chemicals to the flotation pulp. An account of the results obtained

will be found below, but we have not yet applied this method to an operating scale, nor have we decided on using one of the other methods applicable for this purpose, such as leaching.

Table 5 gives an average screen analysis of the feed and the general tailings of the Inspiration concentrator for the months of March, April and May. A segregation is made in the copper assay between sulphide and oxide copper, because, considering the present stage of the art, we feel satisfied with our mill work whenever the sulphide copper content of the mill tailings is low. As will be seen from the tabulations, a better recovery is made on the —200 material than on the coarser constituents of the ore, which proves the point that for ores of the character of Inspiration ore, sliming is not to be feared since the introduction of the flotation process.

OIL CONSUMPTION

Experience has shown that in the flotation treatment of our ores we consume flotation agents up to 1½ lb. per ton of ore. At present, the oil mixture contains around 95 per cent crude coal tar and a little less than 5 per cent of oils derived from the dry distillation of wood.

The different tars that we have tested during the operation of our mill have shown greatly varying qualities as far as their flotation value is concerned. The first tar that we tested and made use of was home-made from domestic coal, and happened to be a very serviceable flotation agent. Since that time we have tested tars from several States, and have found some that are suitable for our purposes, while others are less so, and still others even entirely unsatisfactory. We have obtained satisfactory tar products from New Mexico, Colorado, Missouri and Illinois. These States furnish at present as much as we need for our consumption. For awhile it seemed possible that we might have to import from a long distance the large quantities of tar that we require. During that period we tried to find substitutes, and looked especially toward the utilization of fuel oil for this purpose, but we have not been able to get as good results with any kind of fuel oil as with crude coal tar.

TABLE V—AVERAGE SCREEN ANALYSES FOR THE MONTHS OF MARCH, APRIL AND MAY, 1916 OF FLOTATION FEED AND GENERAL TAILINGS

	FLOTATION FEED				GENERAL TAILINGS					
	Per Cent Weight		Copper Contents		Per Cent Weight		Sulphide Copper Contents		Oxide Copper Contents	
	Cum.	Indiv.	Per Cent	Grams	Cum.	Indiv.	Per Cent	Grams	Per Cent	Grams
Mesh										
+ 65	9.5	9.5	0.45	0.042	9.5	9.5	0.18	0.017	0.12	0.011
+100	21.2	11.7	0.86	0.101	21.2	11.7	0.19	0.023	0.14	0.016
+150	33.5	12.3	1.91	0.235	33.5	12.3	0.11	0.014	0.19	0.023
+200	39.2	5.7	2.69	0.154	39.2	5.7	0.14	0.008	0.19	0.011
—200		60.8	1.85	1.125		60.8	0.06	0.036	0.47	0.286
Totals	100.0		1.657		100.0		0.098		0.347	
Assay direct			1.62				0.101		0.318	
side			0.36						0.419	

Our experience is that we can get along with coal tar alone. It is beneficial, however, to add wood-distillation products in small quantities, for instance, those containing pine oil. While coal tar makes a very strong and heavy froth, such as appears to be required to keep coarse mineral particles in suspension, the wood-distillation products have the characteristic of producing a

multitude of froth bubbles, such as seem necessary to furnish the large surface required to save the very fine mineral particles. Because the finer ore particles, as (slime) on account of their small diameter, expose a large surface, it is evidently necessary to produce a correspondingly large surface of froth in order to save them by flotation.

OPERATING COST FOR FLOTATION

The number of men necessary for the operation of large flotation machines is remarkably small. At the Inspiration plant one operator supervises four sections of flotation machines. Two Mexican helpers assist him in washing the bottoms, thus insuring a free passage of air through the porous medium. At the prevailing high prices of American and Mexican labor, this means an expense of somewhat more than 1.5 cents per ton of ore treated. The total expenses representing flotation proper were as follows for the months of March, April and May, 1916:

	Cents per Ton
Labor.....	1.62
Flotation oils.....	1.65
Other supplies.....	0.35
Power.....	2.14
Total.....	5.76

The subsequent table treatment of flotation tailings, the filter treatment of the concentrates and other operations connected with the process of concentration, belong more or less to flotation treatment, and their expense should also be considered when the cost of the flotation process is to be established. The total milling cost, exclusive of crushing and grinding, has been for the past few months in the neighborhood of 20 cents. When the cost of crushing and grinding is included, the cost is about 40 cents per ton of ore. Royalties for the use of the flotation process are not included in any of these cost figures.

DISCUSSION OF RESULTS OBTAINED

The criticism has occasionally been raised against the Inspiration company that they were slow in deciding on the design of a concentrator. The reason for such slowness was, of course, that the development of the flotation process coincided with the period during which the fundamental points in the design of the concentrator had to be settled. The management, therefore, thought it best to be very conservative in installing standard concentrator equipment, which, in case the new process held what it seemed to promise, might prove to be entirely superfluous. The main point of interest, therefore, is whether it was wise for the company to wait instead of installing a gravity concentrating plant as had been originally considered.

As far as the comparison of a flotation plant, as at present operated by the company, with the gravity-concentration plant, as originally considered, is concerned, the recoveries actually obtained in the company's flotation plant are so much higher than those indicated by tests in the original test mill as being obtainable in a gravity-concentration plant on ore of the same character, that there cannot be the least doubt which system is the better.

In discussing the second question which comes up in this connection, whether for ores of the character of Inspiration ore, gravity concentration supplemented by flotation would be preferable to the simple flotation process that has been adopted by the Inspiration company, the crucial point is this: Can the slime be reduced to lower copper contents by a combined process than by the process followed here? The reduction of the copper in the sand is, as millmen know, simply a

question of fine grinding combined with suitable concentration.

In support of the principle followed by the Inspiration company, I desire to call attention to the screen analyses of our general tailings represented in Table 5. They show that the sulphide copper left in the —200-mesh material is very low.

In addition, the floor space required for a plant like this is materially smaller than for a plant of the combination plan, which also means that the construction cost is much lower; and further the operating costs are low by reason of the greater simplicity of design. I hope these facts are sufficient to decide the point at issue as far as the ore of this district is concerned.

I hope that our neighbors of the Miami company, whose mill was built before the flotation process was known, will uphold me in my statements. If this point is admitted, it will endorse the principle followed in the design of the Inspiration mill, of doing away with reduction in stages and concentration in stages.

It must be granted that the settling of flotation-concentrate pulp requires extensive floor space, as shown by the figures referred to above, and that settling and subsequent filtering absorb a certain fraction of the mill operating costs. However, as a ratio of concentration in the Inspiration mill is 25 into 1, only 1/25 of the ore is thus treated. The actual expenses increase, of course, proportionately for ore which does not permit concentration with such a high ratio as the ore existing in the Inspiration mine. Therefore, there will be a point beyond which a different system of concentration is preferable. Just what the critical ratio of concentration is must be determined by calculation and testing based on individual conditions.

Prospects for Future Development of the Flotation Process

The flotation process is in its infancy. For this reason, therefore, our concentrator must be necessarily in the first stages of its development. In what direction future changes may take place is perhaps indicated by tests which have been made partly on a laboratory scale and partly on a somewhat larger scale, but which have not yet been incorporated into our regular milling process. Of these latent developments I will try to give an outline in the following:

POROUS-BOTTOM EXPERIMENTS

The porous bottom is, as one may imagine, the most essential part of a pneumatic-flotation machine. Our experience with the porous bottoms of the different constructions brought out very clearly the principal difficulty attached to them, which is, that the pores have a tendency to contract gradually and thereby to retard the passage of air through them. This tendency was more pronounced in the solid porous bottoms employed in the Flinn-Towne flotation machine than it was, for instance, in those of the Callow type, although the latter also show a tendency in this direction.

Our first supposition was that the choking was due to the fact that the air entering below the blankets carried particles of dust, which would settle in the fine pores and reduce their area. Indeed, a canvas blanket will, after a certain length of service as a porous medium, always show some ring-shaped spots of dark color opposite the air inlets, clearly indicating that a deposition of dust particles on the blanket actually does take place.

To make sure of this point we cut out round disks from a Callow blanket that had been used for some time and investigated their porosity by using them as porous bottoms in a glass tube standing in a vertical position. Air under pressure could be applied to an air chamber

located underneath these disks, and the air passing through the porous blanket could be measured by a gas meter. The quantity of air discharged through the porous medium offers a measure of the porosity of the blanket, and for this reason the velocity or speed with which the counter of the gas meter revolves, gives an indication of the porosity of the porous disks being tested.

To our surprise, we found that the darkest points of the blanket were not those of lowest porosity. On the contrary, the points farthest away from the air inlet showed the greatest tendency to choke. An explanation of this paradoxical behavior seems to be offered by the fact that an air blanket is kept in a state of more or less agitation near the air inlet (in the Callow machine this happens to be a point remote from the places where it is held rigid) while farthest away from this point the blanket assumes a state of comparative rest. Incrustations, due perhaps to the presence of soluble salts in the water in conjunction with fine slime, always form to a greater or less extent in the top layer of the blanket. Evidently, the agitation counteracts the formation of the incrustation, while there is no such counteracting influence in the portions which are essentially at rest.

For this reason we concluded that a solid porous material is not suitable as a diaphragm in a flotation machine of the pneumatic type, if a bottom of long life is required. As a matter of fact, the experience of everybody who experimented with solid bottoms seems to have pointed in the same direction. Mr. Cole for a while tested out carborundum tubes in his machine. We tried carborundum stones in the flotation machine of the inspiration type and abandoned them, and I believe that even Messrs. Flinn and Towne have, in the meantime, give up the solid bottom of their original design.

A necessary condition for a serviceable flotation bottom appears, therefore, that the porous medium be of a flexible nature. The four-ply canvas stitched every half inch or so which Mr. Callow's first cells contained and which we have used for considerable time in the Inspiration machines, seems to answer this purpose fairly well. We find, however, that to keep it in good working condition and prevent incrustations from forming on the top, we have to clean it frequently. This is done by dipping an iron pipe connected with the water hose into the compartments and sweeping the canvas bottom with the jet of water discharging from the lower end of the pipe.

The canvas blankets seem to last for about six months at the most. As they are inexpensive, the replacing of a bottom after that time is not a serious item in the operating costs. The giving out of the canvas is due to the wear caused by the frequent cleaning. The top layer wears out first, the holes created by the stitching forming nuclei for the formation of larger holes. By the time the top layer has a number of holes the canvas blanket is generally discarded. In the interest of greater economy we intend giving up interstitching the layers of canvas. We are trying to decide whether it is better to use single sheets of thicker fabric or to use canvas similar to the kind that we have been using and to put several layers on top of one another without interstitching them. The latter has the advantage of requiring the discarding of only one layer, when it becomes defective.

There will always be some tendency to form incrustations so long as canvas is used for flotation mediums. Their formation will be entirely prevented only by substituting an altogether different material. We have made experiments in this direction. One of my former assistants, R. H. Haskell, deserves credit for suggesting them. For instance, we substituted for the canvas blankets thin rubber sheets perforated with a multitude

of needle holes and obtained an excellent froth. The objection to their use is that their life is limited. When sheets of rubber of an increased thickness are used, the needle holes require too much pressure to form openings of sufficient size for the passage of air, and to make a thick rubber sheet suitable for this purpose, slits several millimeters long have to be substituted for needle holes. We have had one or two rubber bottoms of this design in operation, but just at present we are not ready to substitute them for canvas blankets. We also tried a blanket made from a material that goes under the name of sponge rubber and can be produced with rather fine texture. We have not been able, however, to obtain lastingly good results from the use of this medium. Furthermore, we tried a woven fabric containing rubber threads in one direction and threads of cotton or the like in the other direction and a rubberized canvas made by the Goodrich Rubber Company. We are not prepared to use any of these materials on a commercial scale.

The advantage of rubber should be, in the first place, that on account of its smoothness it would have less tendency than canvas to permit the formation of incrustations. Besides, an elastic medium should have the additional advantage of avoiding the danger of catching small sand or slime particles in the pores of the medium, as an expansion of the medium (that may be effected, for instance, by increasing the pressure) would widen the pores and remove such particles. We think that our experimental work in this direction is encouraging.

RAISING THE GRADE OF CONCENTRATES

The recovery that it is possible to effect in a flotation plant depends largely on the grade of concentrate desired. With a low grade of concentrate, low tailings can be made, but when a high grade of concentrate is stipulated, increased tailing losses cannot be avoided. A question that suggests itself in this connection, and which we have tried to answer by laboratory experiments, is, "How can we raise the grade of our concentrates—that is, reduce the percentage of insoluble matter contained in them—without entailing additional copper losses?" We know from laboratory experiments that this can be done by expensive methods—for instance, by heating the solutions—but such a procedure would be undesirable from an economical standpoint. Experience has shown us that concentrate produced in the first compartments of the cleaner cells is always freer from soluble matter than the concentrate produced in the last compartments. The problem then resolves itself into finding a suitable cleaning process for the concentrate from the last compartments of the cleaning cells. By treating this low-grade concentrate hot, with the addition of caustic soda, we have been able to separate it into a high-grade concentrate and fairly low tailings. This method necessitates only the expense of heating a small fraction of the pulp and may be a commercial possibility.

RECOVERING CARBONATES BY FLOTATION

Another subject on which we have spent considerable time in our laboratory is the problem of recovering copper carbonates by flotation. When we started our flotation plant we discovered, to our astonishment, that the machines not only saved a high percentage of copper sulphide, but that they also recovered some of the carbonates. Ever since that time we have tried in different means of improving the carbonate recovery.

In the first place, we studied all of the oils seemed to have a tendency to cause the flotation of minerals. Later on we tried other means in

that
of such
addition

to the variations of the oils. One way in which copper carbonates and similar minerals might be recovered was outlined by Alfred Schwartz in his United States Patent No. 807501. The process consists in first artificially producing a sulphide coating on such oxidized minerals by the introduction into the pulp of soluble sulphides, and then adding suitable "oils" and effecting the flotation. If it were possible to thus chemically produce coatings of sulphide identical with the surface of the minerals formed by nature, this process would work well, as evidently the nature of the surface is the only characteristic that determines whether a mineral will float or not.

The Minerals Separation Company owns a number of patents covering this subject. Their English Patent No. 26019, issued to Sulman and Picard, describes the flotation of oxide copper minerals by similar means.

I am not aware that equivalent patents have been issued in the United States. The English patent in question is of a later date than the Schwartz patent above mentioned. The representatives of the Minerals Separation Company have experimented more or less extensively with this system, while demonstrating their machine to the Inspiration company. As far as I know, they have not proved its practicability.

In the course of their experiments they tried the application of sodium sulphide and sodium polysulphide for this purpose. The latter was produced by treating sulphur with hot caustic soda. At the time these experiments were made, I was not familiar with the chemical action taking place, which, as much as I know now, actually results in the formation of polysulphide mixed with thiosulphates and other oxygen-sulphur compounds. The failure of their experiments I therefore ascribed to the fact that perhaps a polysulphide which they were anxious to make was not actually produced.

I proceeded to make sodium polysulphide by a method which I knew, that is, by the treatment of a sodium sulphide solution with sulphur powder. When we applied this reagent to some of our carbonate ores in laboratory flotation experiments, we noted that a good recovery was obtained. The composition of the compound was varied materially in order to find just what composition gives the best results in the flotation of carbonates. Our experience seems to indicate that sodium sulphide alone encourages the flotation of carbonates, but that sodium polysulphide or sodium sulphide, which contains more sulphur than would correspond to the chemical formula Na_2S , gives better results. The addition of caustic soda besides the sodium polysulphide was found beneficial.

The question then arose as to why we succeeded in effecting the flotation of oxidized copper when the experiments of the members of the Minerals Separation staff failed. Tests along these lines brought out the fact that the Minerals Separation compound when applied to our carbonate ores also worked successfully, but that it did not on our regular milling ore. Our own compound when added to our mill ore mixture increased the recovery of the carbonates, but evidently interfered with the sulphide extraction, and for this reason seemed to be of as little use as the compound of the Minerals Separation Company. When applying reagents of this character to tailings resulting from ordinary flotation treatment, with the point of view of effecting a sufficient sulphide extraction by the regular flotation process, and using the compound in question only for the purpose of increasing the carbonate extraction, we have found so far that the increase in copper-carbonate recovery over the one obtained without the addition of such chemical compounds is not worth going after.

But this is only a consequence of the fact that carbonates exist in very small amounts only in our milling

ore and are partly saved by the ordinary flotation process.

There is no real difficulty about saving carbonates by the method mentioned, if they exist in quantities that make it worth while to save them. That copper carbonates can be recovered may easily be demonstrated by treating a deslimed feed in a series flotation machine. If at the point of the machine where the sulphide recovery is nearly finished sodium sulphide is added, the decidedly green color of the concentrates in the following compartments leaves no doubt on this point. The desliming of the feed seems to assist in the carbonate recovery.

It is of considerable (even if only theoretical) value to establish why sodium sulphide and polysulphide tend to increase the recovery of copper carbonates. A coating that might be expected to form cannot be detected. The concentrate resulting from the treatment of pure carbonate ore is decidedly green; besides, when an alkaline condition of the pulp is used there is very little, if any, tendency for any sulphide coating to form, and the alkaline state of the pulp is (as explained above) exactly the condition under which the best carbonate extraction results. Another point that seems to contradict the explanation of these results by the assumption of a sulphide coating is, that when we proceeded exactly as suggested by Mr. Schwartz, *i. e.*, when the application of soluble sulphide was followed by the addition of flotation agents and by the actual flotation—we seemed to obtain poorer results than when the procedure was reversed by applying the oil first and following with the application of some soluble sulphide, although the latter method would certainly seem less favorable to the formation of a sulphide coating, and perhaps for this reason has not been suggested by Mr. Schwartz.

Another theory that has been mentioned as an explanation of this phenomenon is that colloidal sulphur is formed by the solution of sodium polysulphide in water, which, as is known, is a good flotation agent. For instance, it is pointed out in the United States Patent No. 1140865 taken out by Dr. R. F. Bacon of the Mellon Institute in Pittsburgh, that by setting free colloidal sulphur, say by the reaction of a soluble sulphide with sulphur dioxide, good flotation results may be obtained as far as the flotation of sulphides is concerned. To make the process available for the flotation of carbonates and other oxidized copper minerals, he suggests that a sulphide coating be first formed on the minerals, *i. e.*, to follow Mr. Schwartz's idea. Whether the colloidal sulphur by itself has a beneficial influence on the recovery of the carbonate (as has been suggested in explanation of our observations) seems rather doubtful when it is considered that we have obtained good results in alkaline solutions in which colloidal sulphur does not seem to separate out from polysulphide containing only a limited amount of sulphur such as was used in our tests. The full theoretical explanation of these facts must therefore be left to future investigations.

RECOVERY OF SILICATES

In our experiments with the object of saving the oxidized copper minerals, we soon found that we could save some of these minerals, while others were entirely refractory to the method above mentioned. To establish which minerals could be saved and which not, we attempted an analytical separation into carbonates and silicates. The chemical methods which we tried for the purpose of distinguishing between the two proved unreliable, however, and we had to resort to the separation by specific gravity (panning). The carbonates of copper (malachite and azurite) are heavier than gangue, and the silicates (chrysocolla) are lighter. The separation is rather difficult, owing to the small difference in

specific gravity, and the results are therefore far from being altogether reliable, but they seem accurate enough to indicate that the method of saving carbonate copper above referred to is of value only for the recovery of carbonates and does not apply to silicates.

This fact seems to be another corroboration of the assumption made above, that carbonates of copper do not float simply because of the formation of a thin surface coating of copper sulphide. It can easily be verified in the laboratory that silicates can be coated with copper sulphide fully as easily as copper carbonates. For this reason, if the filming theory is right, it should be possible to float silicates just as well as carbonates. There is no doubt that they can be floated by transformation into sulphides, only this transformation must not be confined to the surface, but must go deeper. Our experience is that to effect a good recovery it is necessary to acidify the pulp so strongly that practically all of the silicates of copper are dissolved and by the action of hydrogen sulphide or other soluble sulphides are transformed into the state of chemically precipitated copper sulphide. In this form there is no difficulty about the recovery of the copper by flotation, but this procedure is not entirely without objection.

In case hydrogen sulphide gas is used, the acid combined with copper is regenerated. This tends toward a low acid consumption and a good copper extraction, on account of the fact that the treatment winds up with a small percentage of copper in solution and free acid present, both of which are desirable in the light of the law of chemical mass action. But hydrogen sulphide is not a desirable reagent. The fact that it is a gas and not a liquid introduces complications in the apparatus which are accentuated by the fact that it is poisonous and obnoxious otherwise.

Other soluble sulphides used in place of hydrogen sulphide will neutralize some sulphuric acid with the result that the acid consumption will be higher and the copper extraction lower than in case of hydrogen sulphide gas.

As far as acid consumption is concerned, it is pointed out that the free acid lost with the pulp may be settled out in ponds and re-used. However, the re-use of acid diluted to such an extent is a more serious problem than is generally realized.

The treatment of concentrates that are "colloidal," to a much greater extent than ores which millmen have been in the habit of calling colloidal, offers additional problems, which, however, may prove not to be as serious as they look.

Everything considered, I cannot see that the flotation treatment of oxidized copper ores after previously leaching them offers better prospects than straight leaching by decantation and precipitation by other methods.

General Theory

Very much has been published recently about the theory of the flotation process, and very many suggestions have been made that will probably prove valuable after it has been shown by critical tests how far they explain the facts.

It seems to me that an explanation of the qualities of the flotation oils is not as difficult as it might appear. The problem only seems so complicated because the flotation qualities of an oil or an oil mixture have not been separated into their components. In fact, it requires a combination of qualities to make a successful flotation oil. In the first place, the flotation oil has to coat the mineral particles. That there is a tendency for the formation of such a coating can easily be seen from simple experiments. For instance, if samples of copper sulphide (chalcocite), copper carbonate (malachite) and

gangue (silica) of the same screen size are spread out on watch glasses and then moistened with a drop of coal-tar creosote, it will be seen that the drop of creosote soon disappears through absorption by the copper sulphide, while it takes a much longer time for it to be absorbed by the copper carbonate and a still longer time with the gangue. On the other hand, when a drop of water is placed on the same minerals, it will disappear on the gangue first, later on the carbonate, and finally on the copper sulphide. This evidently proves that in a mixture of water and oil, the oil will attach itself with preference to the sulphide particles while the water will have the greater tendency to wet the gangue.

The second quality which at least is sometimes required of a flotation oil is that it has to form a stable froth. In such a case the stability may be secured by more firmly cementing together the mineral, air and oil. To accomplish this, oils are used which have a tendency to float finely divided gangue particles. The action is characteristic of the heavier pine distillates like pine tar and the lighter ones like turpentine if they are crude, unrefined products; in other words, when they contain some of the heavier distillates. I am not quite sure, however, whether the beneficial influence of oils of this group is not perhaps rather due to the fact that they remove colloidal material from the pulp and thereby improve its tendency to float minerals.

A third quality demanded of a successful oil mixture is that it must be able to produce a sufficient volume of froth. This property is exemplified best by oils of the soluble type—cresol, pine oil, alcohols and other substances. It can easily be proven that when oils of this type are used, although they may be considered insoluble, the water acquires the frothing qualities of the oil. It may be demonstrated by shaking an oil of this character, with water and permitting the oil to separate out again. It will be found that the water has acquired frothing qualities by undergoing this treatment. It is perhaps even likely that the soluble portion of the oils belong to this group is the only portion that is active in this manner. The difference between the oils of group 1 and group 3 may be studied, for instance in a flotation machine of our type. It will be noted that the heavier mineral runs over the concentrate discharge largely in the first compartments forming a heavy, dark froth and the heavy insoluble portions of the flotation oil mixtures apparently go with it. Toward the tailings end of the flotation machines, most of this dark material has disappeared and the froth is lighter and of a more watery nature. The pulp, however, has not lost the quality of forming froth even after it gets to the last compartment of the flotation machines. This permits the conclusion that the frothing characteristics follow the tailings pulp. The water settled out in tanks and tailing ponds has decided frothing qualities. Such water behaves in a similar way to certain alcoholic solutions with which we are used to associate this characteristic, for instance, beer or champagne. The experience of mills using the flotation process, that when the tailings water is reclaimed the quantity of frothing oil may be considerably reduced, further supports the assumption that the formation of froth is caused by water-soluble substances.

Just how the surface tension of water and air must be modified to permit the formation of froth has been made the subject of some speculations recently published by different authors. We have also devoted some thought and a few experiments in our laboratory to this question. A discussion of these matters belongs to the realm of physics, however, and is outside the scope of this paper. But I might add this remark to the discussion of the subject of flotation oils, that most flota-

tion oils not only have the characteristics of one group, but may at the same time possess those of another one. For instance, coal tar has qualities 1 and 3. For the flotation of our ordinary milling ore we do not require much of the quality of oil classified in group No. 2, and, therefore, can get along with coal tar alone. But we find it advisable to add to the coal tar more of the qualities characteristic of the third group, and for this purpose we add about 5 per cent of the total in the form of crude pine oil. In many cases it is found that the flotation oil has the characteristics of group No. 2 to such an extent that it is impossible to make clean concentrates. Various chemical means, such as the addition of acid or alkali, are used to counteract this.

CONCLUSION

In summing up I want to say that the fact that the Inspiration company has been able to design a commercially successful flotation plant and has found ways that hold out prospects of raising the plant to a very high state of efficiency, must be attributed to the policy followed by the company of spending great sums of money for the purpose of investigating the flotation process on a commercial scale. In carrying out these investigations, a close coöperation between laboratory and operating force helped us, I believe, more than anything else. I would like to give credit to each person who had a share in contributing toward the success of the work, but cannot do it, because the list would be too long.

Inspiration Consolidated Copper Company, Miami, Ariz.

Chemical Composition Versus Electrical Conductivity*

By Colin G. Fink

Some years ago, while still at the University, I carried out a number of experiments on the electrothermic production of ultra-marine. Powdered mixtures of sodium sulphide, china clay and carbon were interposed between carbon electrodes in a closed crucible furnace. I observed at that time that in order to keep the electrical resistance and the temperature of the charge fairly low so as to avoid decomposition of the ultra-marine as soon as it was formed, it was necessary to use very finely divided carbon, such as lamp black. With charges made up of powdered coke which was coarse compared to the lamp black, I could not get any appreciable current to pass between the carbon electrodes up to potentials of 250 volts. Subsequently, I have found repeatedly that the electrical conductivity of mixtures of finely divided substances is a function of the relative size of the components.

Experimental

A series of tests was made in order to get values of a more quantitative nature. Two substances were selected, the physical properties of the one as divergent as possible from those of the other: A black metal powder, tungsten, and a white insulator powder, thoria. The advantages in this selection are manifold: Both tungsten and thoria will stand very high temperatures and can therefore be made practically moisture-proof. It is a well-known fact that in all high resistance tests adsorbed moisture is a very disturbing factor. As regards metals such as copper and silver, these were not serviceable since they cannot be heated to high temperatures without partial vaporization, which though slight was sufficient to cover the surface of the insulator granules with a highly conductive film. Other factors that

decided our selection in favor of tungsten and thoria were: (1) high state of purity; (2) availability of both in extremely fine powdered form (readily sifted through 250 mesh silk gauze); (3) constancy and stability under ordinary atmospheric conditions; (4) sharp distinction in color; (5) high specific gravities (which reduced the tendency to dust).

All mixtures here recorded were made up of equal weights of tungsten and thoria. As regards the size of the particles, as stated above, the mixtures would pass readily through silk having 250 meshes to the inch. The holes in this silk are about 0.001 in. in diameter.

Attempts to segregate particles of a well-defined size by such methods as suspending in water, or in organic liquids or in air, were frustrated on account of the persistent tendency of the very fine particles to form agglomerates.

We finally resorted to the familiar "tap test." This gave us fairly good comparative values of the fineness of the various powders used. Ten grams of the powder or powder mixture were filled into a 10 c.c. glass graduate and tapped to constant volume; usually after seven minutes, no further decrease in volume could be detected. The ultimate volume in cubic centimeters divided by 10 gave us the relative volume (v_r) as recorded in Table I. It can easily be demonstrated, that the values for v_r are a function of the density and mean particle size. At first there seemed to be a serious objection to the tap test, namely this, that a powder composed of say, equal parts of coarse and fine particles would give the same value for v_r as a second powder whose particle size was a mean between the two limiting sizes of the first powder.

This objection to the tap test was automatically set aside since in the ordinary preparation of metal or oxide powders in single small lots by far the greater majority of particles are approximately of the same size. This tendency to form a "standard" size is a universal phenomenon, the dimensions of any particular standard being dependent upon the physical factors such as temperature, strength of solution, etc., under which the particular powder is prepared. Compare in this connection the uniform size of the crystals of granulated sugar as regulated by the "strike pan."

TABLE I

Mixture	Relative Volume (V_r) of ThO_2 W		Mixture Found	Mixture Calculated	Appearance of Mixture
R	.720	.113	.430	.417	White
P	.720	.350	.565	.535	White
Z	.576	.235	.389	.406	White
T	.305	.113	.200	.209	White
S	.305	.330	.275	.318	Black
X	.238	.577	.420	.408	Black

Referring to Table I, we note that the white thoria powders varied in relative fineness between 0.720 and 0.238 and the black tungsten powders between 0.577 and 0.113. In column 5 the calculated value for v_r of any mixture is equal to one-half the sum of the v_r values of the ThO_2 and W constituents. These calculated values agree fairly well with the experimental and support our contention that the particles of any freshly prepared powder are of fairly uniform size. If this were not the case no such agreement between the values of columns 4 and 5 were possible. In the last column of the table is given the appearance of the mixture, whether nearly white or nearly black. If the v_r value for the white powder is high as compared with the v_r value for the black powder, the appearance of the mixture is white; if the white powder is coarser than the black powder, the appearance of the mixture is black. In other words, whenever the ratio of v_r for thoria to v_r for tungsten

*A paper presented at the New York City meeting of the American Chemical Society in the Symposium on Colloids, on Sept. 28, 1916.

is greater than 2, the mixture is white and if less than 2 the mixture is black, where 2 is equal to the absolute density of tungsten (19.6) divided by the absolute density of thoria (9.8).

Electrical Measurements

The powders were pressed into rods 4 cm. long and $\frac{1}{2}$ cm. square. They were then placed into a tungsten hydrogen furnace and fired at 1600 deg. to 1650 deg. for three hours. This firing caused the rods to sinter together and rendered them practically proof against moisture. The fired rods were kept in a P_2O_5 desiccator. The rods were then mounted between brass clamps and the resistance measured on a Wheatstone bridge with a sensitive galvanometer. Care was taken to make these measurements on days when the humidity of the air was low. (Compare in this connection H. L. Curtis, Phys. Rev., 3, 490 "Surface Leakage over Insulators.")

In view of the differences in "color" of the various mixtures in the powdered form, it was not very surprising to find marked differences in the electrical resistances. The firing at 1600 deg., however, resulted in an almost uniform shade for all of the mixtures. In the table (II) below are recorded four of the characteristic resistance values found.

In the last column are the calculated specific resistance values.

TABLE II

Powder ThO ₂ No. 2	Resistance Over 10 ¹² Ohms	Resistivity Over 10 ¹¹ Ohms
Z	41.8	173.0
X	0.0271	0.108
W No. 1	0.0040	0.016

The powders, ThO' No. 2 and W No. 1, were pressed up into rods of the same size as those of the mixtures; they were likewise fired at 1600 deg. for a period of three hours.

Since in all of our original powders a small percentage of grains was present whose size was considerably smaller than that of the majority of the grains, our results would tend to show that under ideal conditions of mixture, relative grain size, uniform distribution, etc., the resistivity values for white mixtures such as Z would be even higher than here recorded. Similarly, the resistivity values for black mixtures such as X would be even lower than those found, approaching a limiting value equal to twice that of the 100 per cent metal rod.

Conclusion

In general we may say that the electrical conductivity of a substance is primarily dependent upon the shape and the distribution of the fundamental grains or particles composing the substance, and secondly, upon the presence or absence of thin films of secondary material enveloping these ultimate grains.

On the basis of this theory we can account for the comparatively high conductivity of gels that contain but a trace of conducting material. We can also account for the marked difference in resistance for example of two samples of commercial copper, whose chemical composition is identical, depending upon whether the impurity, such as sulphur, is uniformly dissolved in the metal or whether it forms a film ("cement") of copper sulphide around pure granules of copper. The latter case is to be regarded, as Bancroft suggested, as an emulsification of copper in copper sulphide. The high resistance of these surface films composed of say sulphide or oxide or arsenide accounts for the high resistivity values of copper when but a trace of the impurity is present.

Electrolytic Zinc Dust*

By Harry J. Morgan and Oliver C. Ralston

The sudden increase in the price of zinc dust after the beginning of the European war, owing to the cutting off of the German and Belgian supply, led to the conducting of some experiments on the possibility of its production on a commercial scale from solutions of zinc, and the substitution of the zinc made in this manner for the zinc dust ordinarily used in the precipitation of gold and silver in the cyanide process.

As the Salt Lake City station of the U. S. Bureau of Mines, in co-operation with the Department of Metallurgical Research of the University of Utah, is carrying on investigations that have for their object the treatment of low-grade and complex zinc and lead ores or products, it was thought well to determine whether the zinc contained in such ores and products could not be utilized in the manner above indicated, and so supply the demand which had arisen for zinc dust.

The United States, in 1913, imported 4,382,470 lb. of zinc dust, valued at \$227,585. Most of this was from either Germany or Belgium. The domestic production, in comparison with the imports, was very small. In the years 1912 and 1913 the domestic production was 492 and 423 tons respectively, while the imports were 2,400 and 2,200 tons respectively. For a time the zinc dust made in zinc smelters was a drug on the market and when first utilized in cyanidation could be bought for a lower price per pound than solid zinc. After the advantages of the use of zinc dust for precipitation were realized, so much zinc dust began to be used for this purpose that it brought a premium of about 3 cents per pound over what the value of spelter was at the beginning of the war. Since that time its price has averaged about 30 cents per lb., without much fluctuation. South American zinc smelters have undertaken to supply the demand but their product has never been equal to the German zinc dust.

Some attempts by Morgan¹ were made in the application of a jet of air to atomize a column of molten zinc for making zinc dust. This work was carried on at the Bureau of Mines Exhibit at the San Francisco Exposition, but the zinc dust was not satisfactory for cyanide precipitation. While it was fine enough to pass a 200-mesh screen, it was only 25 per cent efficient in the precipitation of silver from cyanide solutions and a microscopic examination showed that the small pellets of zinc were in the shape of congealed droplets which present a minimum of surface for reaction with the silver cyanide solution. This idea has been further carried out at Anaconda and we are informed that 10 to 15 tons of atomized zinc is now being prepared per day, in preference to sponge zinc made by electrolytic deposition from sulphate solutions. This dust is being used for purification of zinc sulphate solutions, for the reason that the more finely divided electrolytic sponge tended to clog up the Shriver filter presses used at that plant.

To us, a better idea seems to be the making of a zinc sponge by electrolytic methods, the sponge to be of such a nature that it would crumble to dust when dried. The variety of electrolytic conditions available,

*A paper read at the New York meeting, American Electrochemical Society, September 28, 1916, by permission of the Director, U. S. Bureau of Mines. Communicated by D. A. LYON, Metallurgist in Charge of Salt Lake Station of Bureau of Mines. Mr. H. J. Morgan is Research Fellow, University of Utah; O. C. Ralston is Assistant Metallurgist, U. S. Bureau of Mines, at the Salt Lake Station.

¹In this work Morgan was assisted by Dr. R. H. Bradford, Professor of Metallurgy, of the University of Utah, and the work was carried out under the direction of C. H. Clevenger, Professor of Metallurgy at Stanford University.

with the different electrolytes which can be used, and the resulting great differences in the physical properties of the precipitated metal, gave promise of the possibility of a zinc dust which would be highly efficient and rapid. As a result of the experimental work, which has been carried on, it is believed that this possibility has been realized. In addition to its use for precipitating gold and silver from cyanide solutions, zinc dust can also be used in sherardizing, and for chemical purposes, such as reduction of organic compounds, etc. Sherardizing requires a considerable proportion of relatively coarse particles of zinc, similar to the atomized zinc above mentioned, but it is possible that the manufacture of dyes and other such chemicals in the United States can create a considerable demand for electrolytically prepared zinc dust of high purity and efficiency. The following work was carried on with a view to preparing dust satisfactory for cyanide practice and does not consider the needs of the sherardizing industry, or of the chemical industries.

According to Sharwood,² zinc dust for use in cyanide precipitation should be fine enough so that 90 per cent of it will pass 200 mesh and it must be high in metallic zinc. A considerable amount of zinc oxide may be present without seriously affecting the efficiency of precipitation by the metallic zinc. The following method of testing the efficiency of precipitation by zinc dust is given by Sharwood. After passing the dust through a 100-mesh screen to break up the lumps, 303 milligrams are weighed out and added to 250 cc. of 1 per cent silver cyanide solution which contains 0.15 per cent free cyanide. The solution is stirred occasionally for two hours, after which it is withdrawn from the precipitated silver by filtration. The precipitated silver is dissolved in nitric acid and titrated with ammonium sulpho-cyanate, using a ferric salt as an indicator; or else the precipitated silver is scorified and cupelled to be weighed. Each milligram of silver precipitated represents 0.1 per cent efficiency of precipitation. This test is merely an empirical one of general acceptance which is admittedly near enough to allow of intelligent buying of zinc dust. It is stated by Herz³ that the efficiency of zinc dust should be over 40 per cent and that dust with less than 30 per cent efficiency generally gives poor results. Dust of over 50 per cent efficiency is hard to obtain. The average grade of zinc dust from Europe is 45 per cent efficient, but in this work we have been able to get dust giving an efficiency of 74 per cent.

The usual endeavor of the zinc hydro-electro-metallurgist is to obtain solid reguline deposits of zinc rather than the sponge, as the sponge metal can rarely be melted down into spelter. The literature on electrolytic zinc is full of instances where work along certain lines was stopped on account of the "tendency" of the zinc to be deposited in a spongy form. However, we found that in duplicating this work and following the conditions as given, that there is only a *tendency* and that the average result of such conditions is trees, warts, or loose crystalline zinc. We found as much difficulty in obtaining a true sponge as the beginner usually finds in getting smooth solid deposits. Conditions of high current density and low current density, high acidity and low acidity, or basicity, high temperature, etc., were tested and it was very hard to get all the sponge that others had reported as being so easily obtained.

The writers have been informed that one metallurgical company produced several thousand pounds of

zinc dust at their electrolytic zinc plant in Welland, Ontario, by allowing the temperature of their solutions to go up above 70 deg. C. and that it was used by one of the local firms with indifferent success. The electrolytic plant in question is operating a sulphate solution of zinc in which ore is suspended in the solution while the cathodes are protected by bags. Most of the sponge or the loose crystals prepared by us from sulphate solutions did not possess a very high precipitating efficiency. Spongy zinc was formed when solutions of zinc sulphate containing dissolved zinc oxide were used, but as soon as the solutions became acid, due to the formation of sulphuric acid at the anode, the zinc lost most of its spongy characteristics. An excess of zinc oxide suspended in an open cell is not desirable, as it mixes with much of the loose zinc sponge formed. Removal of the solution to an outside vat, for treatment with zinc oxide, is not desirable on account of the slow and low solubility of the zinc oxide in the zinc sulphate solutions.

The method of adding impurities to the solution was resorted to in order to get sponge zinc. Copper and arsenic were found to be most efficient for this purpose, but copper is not a desirable constituent in zinc dust on account of its presence in the precipitate of the precious metals. Arsenic is also undesirable in the precipitate, if the latter is to be treated with sulphuric acid before melting into bullion, due to the formation of poisonous arsine. All the copper was found to be deposited quite quickly from solution with the sponge zinc, but after the deposition of the copper, the zinc deposits began to be more solid and crystalline. A continual drip of copper sulphate into the electrolytic vat is hence necessary. The addition of iron as an impurity did not result in producing successful sponge zinc. Furthermore, the oxidation and reduction of iron salts at the electrodes lower the current efficiency.

The favorable results obtained in solutions made slightly basic encouraged the use of basic solutions of zinc, such as sodium zincate. The zincates allowed a wider latitude in the precipitation of zinc sponge than any other solutions tested. Lead anodes tend to dissolve, and zinc anodes dissolve almost quantitatively. Iron anodes are practically unaffected, especially those made of the better grades of iron. After doing this work it was discovered that practically the same idea had been patented by Sherard Cowper-Coles in British patent 13,977 of 1907. The electrical conditions best for this work are not mentioned by him, but we find that a wide range of voltages are allowable, and most of our work has been done at a current density of about 300 amp. per sq. ft. (3225 amp. per sq. m.). Cowper-Coles mentions the possibility of using galvanized "hard zinc" for anodes when making sponge zinc, as the iron is not dissolved, while the zinc is, thus lowering the operating voltage and replenishing the solution. He also recommends the use of a rotating vertical disc of a cathode, a form of cathode which we had adopted after some considerable test work. The disc can be made of iron and the upper half projects out of the electrolyte. The sponge is scraped off the disc into water as the disc slowly revolves. Rapid rotation of this disc is not allowable, as the better agitation of the electrolyte causes the formation of adherent zinc which defeats our purpose. To have a barely perceptible motion of the disc is sufficient. We had anticipated trouble in the drying of the dust, but met with none, as we found it could be heated to 250 deg. C. on the hot plate in the open air without ignition. The washing of the sponge free from the adhering solution of sodium zincate must be performed with weaker caustic, as the zincate hydrolyses in water solution to

zinc hydrate and sodium hydrate. A water wash can follow a caustic soda wash. The dust prepared in this manner was highly efficient (over 70 per cent).

The data, obtained as a result of some of the tests performed, are summarized below.

Test 1—50 per cent $\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$ solution at 60 deg. C.; lead anode; iron cathode; current densities, 1 to 15 amp. per sq. ft. (11 to 162 amp. per sq. m.). Warty deposit. At boiling temperature a crystalline warty deposit is obtained.

Test 2—10 per cent Zn and 1 per cent ferrous iron in sulphate solution. Current density 15 amp. per sq. ft. (162 amp. per sq. m.); voltage, 3.5. Deposit warty to loosely crystalline. Improves slightly on raising current density to 245 amp. per sq. ft. (2633 amp. per sq. m.).

Test 3—Neutral solutions of $\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$, 15 per cent. Current densities of 8 to 15 amp. per sq. ft. (86 to 162 amp. per sq. m.). A small amount of ZnO added. Anode of zinc. Result, a fair sponge.

No. 1. Fairly coarse material, precipitation efficiency.....68.6%
No. 2. Fine material; precipitation efficiency.....70.1%
No. 3. Coarse material; precipitation efficiency.....64.9%
No. 4. Coarse material; precipitation efficiency.....65.6%

Test 4—Neutral solution of zinc sulphate like above, 3 per cent Zn. The electrolysis was continued until the acidity increased to a point where the zinc became platy and coarsely crystalline. The precipitation efficiency of the zinc was 65 per cent.

Test 5—20 per cent zinc chloride solution containing dissolved ZnO. Current density 500 amp. per sq. ft. (5375 amp. per sq. m.). Two successive samples of sponge taken. Efficiency of first test 60 per cent, of the second, 45 per cent. The sponge prepared from this solution showed a strong tendency to oxidize on drying.

Test 6—Solution of zinc sulphate, containing 5 per cent Zn and 2 per cent sulphuric acid. Anode of "galvanizers dross." After most of the acid has been used up (during which time a fairly good smooth deposit of zinc was obtained) the deposit became spongy and the zinc dust gave a precipitation efficiency of 56 per cent.

Test 7—Sodium zincate solution. 25 per cent caustic, 6 per cent Zn. Carbon anode. Iron cathode. Electrolyzed down to solution of 2.5 per cent Zn. Three periods of 15 minutes, during which the zinc sponge of each period was collected separately.

No.	Voltage	Current Density	Current Efficiency	Ppt. Efficiency
1	4.7	260 amps. sq. ft.	83.0%	60.5%
2	4.6	270 amps. sq. ft.	85.4	57.0
3	4.7	250 amps. sq. ft.	69.2	56.0

Test 8—Sodium zincate solution. 22 per cent NaOH, 6 per cent Zn. Iron anode and cathode, reduced in 15 minutes to 5 per cent Zn. 4.6 volts. Current efficiency 90.7 per cent and precipitation efficiency of sponge, 65.5 per cent.

Test 9—Sodium zincate solution. 25 per cent NaOH; 6.5 per cent Zn at beginning and 1.5 per cent at end of test. Lead anode, iron cathode. Lead anode slowly dissolved, and solution became more caustic, necessitating the addition of more zinc oxide. Three periods in test, the second starting when strong alkalinity developed.

No.	Zn.	Pb.	Eff. Pptn.
1	94.5%	4.5%	55.5%
2	79.5	16.6	39.6
3	68.5	23.6	34.7

Test 10—Sodium zincate solution as in Test 8. Disc cathode rotation barely perceptible. Sponge of 70 per cent precipitation efficiency.

Test 11—Sodium zincate solution. 8.9 per cent Zn

at beginning and end of electrolysis. Iron disc cathode. Zinc anode. 330 amp. sq. ft. (3548 amp. per sq. m.) 4.5 volts. Current efficiency, 54.2 per cent. Precipitation of dust 74.5 per cent. Analysis of dust shows 97.5 per cent Zn.

Test 12—Sodium zincate solution 30 per cent NaOH, 8.9 per cent Zn at beginning and 3.46 per cent Zn at end of 5 hr. electrolysis at 5 volts. The electric current efficiency was determined at short intervals as follows:

Time, Min.	Current Eff.	Precip. Eff.
30	58%	74%
60	71	—
90	60	—
120	59	—
150	65	—
240	62	—
300	53	74.2

The dust on analysis showed 97.5 per cent Zn. The average current efficiency in the deposition of the zinc was about 60 per cent, and one pound of dust requires somewhat less than 3 kw. hr.

From Test 12 it can be seen that the best zinc dust was prepared from a solution containing about 30 per cent of caustic soda and saturated with zinc oxide. A high current density with the corresponding temperature seems to be the best conditions for obtaining highly efficient zinc dust. This causes a higher electric energy consumption than one might wish, but the figure of 3 kw. hr. per lb. (6.6 kw. hr. per kg.) of zinc dust is very safe in being high.

Test 9 shows the effect of the addition of lead to the zinc dust. It can be seen that the presence of much lead in the zinc dust is certainly undesirable. Zinc shavings are often given a bath of lead acetate in order to form a zinc lead couple which will be more efficient in precipitation of the precious metals. We do not know whether the lead deposited with the zinc in these tests was in the proper physical condition to allow the setting up of an electrical couple, as the appearance of the zinc dust did not give any indication of its physical condition. At any rate, over 4 per cent Pb in the zinc dust prepared by this method would seem to be detrimental to efficient precipitation. The lead anode undoubtedly dissolves as the plumbite, which is known to be soluble in caustic alkali. In case it were ever found to be desirable to have a small amount of lead in the electrolytically deposited zinc, a small auxiliary lead anode could be used of sufficient area to give the desired percentage of lead in the zinc dust.

Test 11 shows that a zinc anode can be used in order to keep the solution approximately constant in composition. In this case the arrangement serves only as a medium for transforming spelter into zinc dust. This point is of importance, as it should allow the manufacture of zinc dust at each mill from the spelter usually bought for turning into zinc shavings. It is possible that the zinc smelters could be induced to cast the zinc into anodes instead of the regular bars. It was somewhat of a surprise, however, to find no decrease in voltage where a soluble anode was used, as compared to an insoluble anode. This is possibly due to the extraordinarily high current density used.

Care of Zincate Solutions.—Some question arises as to the best way to utilize the zincate solutions in preparing zinc dust. It might be possible to treat roasted zinc ores or naturally oxidized ores with a solution of caustic alkali, leaching out the zinc as a zincate. It would also be possible to prepare the zincate from zinc oxide, purchased on the market. Since iron in the zinc oxide does not affect the properties of the zinc sponge, it might be possible to keep the solution up to strength by the addition of zinc oxide which is too contaminated with iron oxide to pass as a pigment.

The caustic solution takes up carbon dioxide from the air, forming sodium carbonate. On account of the strong solution of caustic required there is question as to the recausticizing of this solution by lime. According to Lunge,^{*} the speed of the reaction between sodium carbonate and quicklime depends upon the temperature. Equilibrium is reached in 2 to 3 hr. at 108 deg. C., in 12 hr. at 80 deg. C., and more than 40 hr. at 62 deg. C. Further, in 20 per cent caustic solution the reaction comes to an equilibrium at 90 per cent completion, leaving some undecomposed carbonates in the solution. How serious this point is liable to be in practice we are unable to say.

In testing the leaching of several oxidized ores with caustic soda solutions it was found that it was very hard to get extractions of as much as 50 per cent, either by treating calcined or raw oxidized ores. It is known that ignition renders zinc oxide more difficult of solution in the caustic, but the average raw zinc "carbonate" ore will not allow of more than about 30 per cent extraction of zinc, while a calcined sample in this instance gave as high as 50 per cent extraction. Anyway, it is probable that the carbon dioxide from a zinc carbonate ore would tend toward speedy fouling of the electrolyte. Hence we do not consider as practical the proposition to make up the solutions from "carbonate" ores.

In case a spelter anode is used the question of preparation of the solution assumes small importance, and the only serious difficulty to be considered is that of fouling the solution with carbon dioxide taken up from the air. So far as our work is concerned this is still a problem.

Costs.—Due to the high consumption of electrical energy, 3 kw. hr. per lb. (6.6 kw. hr. per kg.) of zinc dust, the principal item to be considered is the cost of electric energy. The high efficiency of the zinc dust in comparison with ordinary zinc dust and the high efficiency of the latter in comparison with zinc shavings precipitation, will probably allow of considerably higher cost per pound for the new dust than for zinc shavings, or ordinary commercial zinc dust.

The high current density used allows of smaller electrolytic tank equipment than is used in most electrolytic installations. The design of a small set capable of supplying the ordinary small cyanide mill with zinc dust is hence a matter of interest. We believe that the figures presented allow of the design of such plants, but until a semi-commercial plant has been built and tested out thoroughly it is needless to present possible designs. The object of this work, as likewise of other investigation which has been conducted by the Salt Lake station of the Bureau and the Department of Metallurgical Research of the University of Utah, has been to test out various ideas and suggestions with a view of determining whether or not they possess sufficient merit to warrant their being tried out on a semi-commercial or commercial scale.

CONCLUSIONS

1. By depositing a "sponge" metal from solutions by electrolysis it is possible to get a zinc product that on drying crumbles into "zinc dust."

2. Sponge metal can be obtained from zinc sulphate solutions by the continual addition of a small amount of either copper or arsenic salts to the electrolyte. The objection to the use of zinc dust prepared by this method is the needless dilution of the bullion caused by the copper, and the danger met in the handling of gold or silver precipitates when arsenic is used to produce the sponge. These difficulties are probably not insur-

mountable. Fairly impure solutions can be worked only when zinc sponge is desired, and this will not handicap the ordinary electrolytic methods.

3. The preparation of zinc sponge is also possible from sulphate solutions by keeping acidity low and temperature high. Zinc oxide, rendering the solution slightly basic, is the most desirable chemical for maintaining this condition. It is subject to the objection that it is only slightly soluble in zinc sulphate solutions.

4. The same remarks apply to zinc sponge prepared from chloride solutions, except that the zinc sponge seems to be more inclined to be oxidized during drying.

5. Sodium zincate solutions allow of the deposition of zinc sponge under a widely varying range of electrical and thermal conditions. Stirring of the electrolyte must be avoided. Current efficiencies of about 60 per cent and zinc dust precipitating efficiencies of 70 to 75 per cent are possible. There seems to be no difficulty in getting 1 lb. of zinc dust from a solution of zinc, with 3 kw. hr. of energy.

6. Sodium zincate solution recommends itself because of its ease of preparation from caustic soda and zinc oxide, both of which are articles of commerce. The zinc tenor of the solution can be maintained either by the addition of more zinc oxide or by the use of zinc anodes, by which latter process spelter can be converted into zinc dust.

The Constitution of Liquids with Especial Reference to Surface Tension Phenomena*

By Irving Langmuir

The epoch-making work of Laue and Bragg has given us a clear insight into the structure of crystalline bodies. In the case of inorganic crystalline substances, it has been found that the atoms are arranged according to definite lattices so that certain groups of atoms are repeated in a regular manner. In this arrangement, however, there is nothing to indicate where one group ends and the next begins. Thus, in a crystal of common salt, the chlorine and sodium atoms alternate in regular order, but are not grouped together into pairs. Any division of the crystal into molecules is thus purely arbitrary. We must therefore conclude that solid bodies are not built up of molecules, but of atoms arranged in definite ways; or rather, we should regard a crystal as a single large molecule.

From this viewpoint the forces holding solid bodies together (cohesion, etc.) are chemical forces, and phenomena such as evaporation are strictly chemical phenomena. So far, in the study of crystal structure, only inorganic bodies have been investigated. It is certain that in solid organic bodies the atoms are arranged in groups which are usually identical with the molecules found when the substances exist as vapors. We may call these *group molecules*. There are good reasons for believing that in crystals of an organic substance these group molecules are held together by chemical forces (secondary valence) to form single large molecules.

A similar theory is now proposed for the structure of liquids. Each atom in a liquid is regarded as being chemically combined with all adjacent atoms. This chemical union may in general be of two kinds, characterized by *primary* and *secondary* valences. The atoms held together by primary valence usually constitute *group molecules*, in which the atoms are more or less rigidly attached to each other in definite arrangements. The secondary valence serves to hold the group molecules together. In very many cases (such as most in-

*An abstract of a paper read at the New York City meeting of the American Chemical Society, September, 1916, in The Symposium on Colloids.

organic liquids) the group molecules are very much simpler than the usual "chemical molecules" and may often be entirely absent. Thus, in such substances as water, concentrated sulphuric acid or in molten salts or metals, there are probably no group molecules at all; the atoms being held together by secondary valences.

A drop of liquid is thus regarded as a single large molecule. In fact, the whole earth, including the oceans (but excluding the atmosphere) may be looked upon as a single molecule.

The most essential difference between liquids and solids is the mobility of the former. The chemist is already familiar with a mobility between different parts of a molecule and has given the name tautomerism to this phenomenon. The mobility of liquids is therefore a result of tautomeric re-arrangements of the atoms.

Evaporation, condensation, freezing, melting, solution, adsorption, and surface tension, and even viscosity, are thus chemical phenomena, and chemical knowledge already available may be directly applied in their study.

This theory has been applied with marked success in the study of the adsorption of gases by solids. Adsorbed gases are regarded as being chemically combined (either primary or secondary valence) with the atoms forming the surface of the solid. The adsorbed film thus usually consists of a single layer of atoms or group molecules, which forms a continuation of the structure of the solid. The effect of such films on the catalytic activity of surfaces (as, for example, platinum) depends entirely upon the nature and the arrangement of the atoms forming the actual surface of the solid.

In a similar way a theory of surface tension is now proposed in which the structure of the *surface layer of atoms* is regarded as the principal factor in determining the surface tension (or rather surface energy) of liquids. This theory is supported in the most remarkable way by all available published data on the surface tension of organic liquids.

According to this theory, the group molecules of organic liquids arrange themselves in the surface layer in such a way that their active portions are drawn inwards, leaving the least active portion of the molecule to form the surface layer. By "active portion" of a molecule is meant a portion which is characterized by a strong stray field (residual valence). Chemical action may be assumed to be due to the presence of electromagnetic fields surrounding atoms. Surface tension (or surface energy) is thus a measure of the potential energy of the electromagnetic stray field which extends out from the surface layer of atoms. The molecules in the surface layer of the liquid arrange themselves so that this stray field is a minimum.

The surface energy of a liquid is thus not a property of the group molecules, but depends only on the *least active portions of the molecules* and on the manner in which these are able to arrange themselves in the surface layer.

In liquid hydrocarbons of the paraffin series, the molecules arrange themselves so that the methyl groups (CH_3) at the ends of the hydrocarbon chains form the surface layer. The surface layer is thus the same, no matter how long the hydrocarbon chain may be. As a matter of fact, the surface energy of all these many different substances from hexane to molten paraffin, have substantially the same surface energy—namely, 46 to 48 ergs per square centimeter, although the molecular weights differ very greatly.

If, now, we consider the alcohols such as CH_3OH , $\text{C}_2\text{H}_5\text{OH}$, etc., we find that their *surface energies* are *practically identical with those of the hydrocarbons*.

The reason for this is that the surface layer in both cases consists of CH_3 groups.

With such substances as CH_3NO_2 , CH_3I , we find that the surface energy is much greater than that of the hydrocarbons. This is due to the fact that the volume of the I or the NO_2 is so great that the surface cannot be completely covered by the CH_3 radicals. The forcing apart of these groups increases the surface energy.

Particularly interesting relations are found with benzol derivatives.

In benzol itself, the group molecules arrange themselves so that the benzol rings lie flat on the surface, since the flat sides of these rings are the less active portions of the molecules. The surface energy of benzol is about 65 ergs per square centimeter.

If, now, an active group, such as OH, is substituted for one of the hydrogens in the benzol (forming phenol or carboic acid), this group is drawn into the body of the liquid, *tilting the benzol ring up on edge* and raising the surface energy to about 75 ergs per square centimeter, which corresponds to the activity of the perimeter of the benzol ring. Thus *any active group* strong enough to tilt the ring up on edge raises the surface energy to about 75. Two active groups side by side (ortho position) have no greater effect than one. But two active groups opposite one another (para position) cannot both go wholly below the surface, so that the surface energy then becomes abnormally large (about 85 in case of para nitrophenol). The substitution of methyl or ethyl groups in the benzol ring lowers the surface energy except where an active group in an adjacent position draws these groups below the surface.

Some of the best evidence in support of the new theory is derived from experiments on thin films of oil on water or mercury. Oleic acid on water forms a film one molecule deep, in which the hydrocarbon chains stand vertically on the water surface with the COOH groups in contact with the water.

Acetic acid is readily soluble in water because the COOH group has a strong secondary valence by which it combines with water. Oleic acid is not soluble because the affinity of the hydrocarbon chains for water is less than their affinity for each other. When oleic acid is placed on water the acid spreads upon the water because by so doing the COOH can dissolve in the water without separating the hydrocarbon chains from each other.

When the surface on which the acid spreads is sufficiently large, the double bond in the hydrocarbon chain is also drawn down on to the water surface, so that the area occupied is much greater than in the case of the saturated fatty acids.

Oils which do not contain active groups, as for example pure paraffin oil, do not spread upon the surface of water.

The measurement of the area of water or mercury which can be completely covered by a given amount of a substance affords an accurate method of determining the shapes of group molecules. Thus it is found that the molecules of stearic acid on a surface of water have a length of about 23×10^{-8} cm. and cover an area of 24×10^{-18} sq. cm. These measurements prove that the molecules are not spherical but are much elongated.

This theory also affords an explanation of the mechanism by which colloids are formed. If a film of closely packed oleic acid molecules covers the surface of water to which sodium hydroxide has been added, OH groups are adsorbed by the COOH radicals, causing an expansion of the lower side of the film without a corresponding expansion of the upper side. This results in the bulging of the film downwards in spots so that

it finally detaches itself in the form of particles, the outer surfaces of which consist of COOH groups together with the adsorbed OH, while the interior consists of the long hydrocarbon chains.

The size of the colloidal particles is determined by the difference in size between the two ends of the molecules just as the size of an arch is dependent upon the relative sizes of the two ends of the stones of which the arch is constructed.

In the final publication of this paper the bearing of the shapes of molecules on the formation of colloids will be discussed in detail.

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Coal and Coke By-Products as a Source of Fixed Nitrogen*

By Horace C. Porter

My purpose in addressing you on the subject of fixed nitrogen from coal carbonization is to call attention to the present remarkable growth of by-product coke making in this country, and to dispel if possible certain illusions relative to this industry. The supply of fixed nitrogen from coal now available as a by-product of coke and gas making is much larger than is generally realized and its importance has in some quarters been unduly depreciated.

In order to drive home in the beginning the principal point of this paper, attention is to be drawn especially now to one actual figure, illustrating in forceful manner the relation of coke by-products' growth to preparedness.

The increase in capacity for ammonia production at by-product coke plants due to new establishments now

*A paper read at the New York City meeting of the American Chemical Society.

building and those put into operation in 1916 amounts to 46,400 tons of ammonia (NH_3) per year. Taken together with the present producing capacity of gas works other than coke ovens (the equivalent of 12,500 tons of ammonia per year), this increase in capacity more than meets the Government's estimate of the requirement of the United States for fixed nitrogen for munitions of war. In other words the producing capacity of coke ovens as it stood in 1915, need not be touched for this emergency; the assured increase in 1916 and 1917 will in itself provide an adequate nitric acid supply for war needs.

From the curves in Fig. 1 may be seen the rapidity of the increase in the last few years. In the four years from 1914 to 1918, 56,000 tons will have been added to the producing capacity of coke ovens, an amount nearly equal to the entire previous growth of the industry during the twenty years of its history in this country.

The Problem of Nitrogen Preparedness

The sustaining of life on the earth depends upon the absorbable nitrogen in plant foods; the destruction of life in war requires the use of fixed nitrogen in explosives. For plant life nitrogen in combined form is essential and must be artificially supplied in many localities; for all known military explosives, nitrogen in the form of nitrates or nitric acid, is absolutely indispensable.

The nation, therefore, has become aroused naturally and rightly to an intense interest in the question of nitrogen supply. The great European war and a realization of America's lack of military preparedness are largely responsible for this interest at the present time.

In view of recent legislation by Congress providing for investigation of this matter and eventually for the building of a Government nitrate plant, it is well now

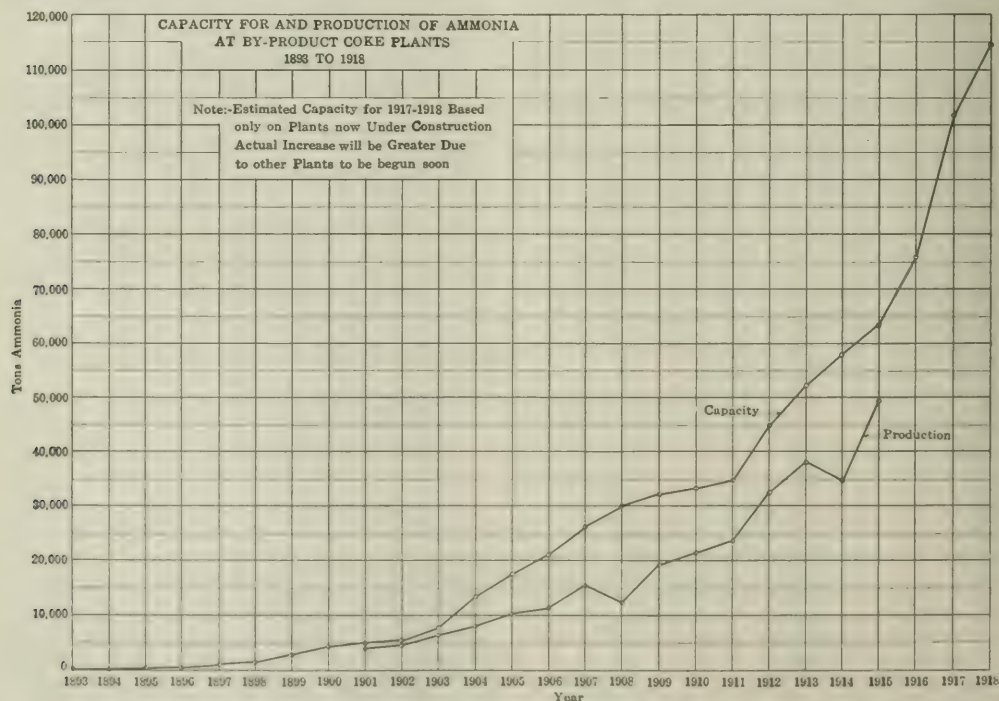


FIG. 1—CAPACITY FOR AND PRODUCTION OF AMMONIA AT BY-PRODUCT COKE PLANTS, 1893 TO 1918

to take account of stock and let the nation be informed as to its present resources in fixed nitrogen, particularly in those obtainable from coal.

We have need of correct and authoritative information on this subject, for a great deal of misleading and unfortunate misinformation has been put before the public within recent months, much of it no doubt unintentional and due to ignorance.

Ammonia is the most available source of nitric acid when Chili saltpeter is not at hand. The contact process of oxidation of ammonia has been put on a practical manufacturing basis and on an immense scale in Germany. Experiments in our own country have gone far enough to prove it feasible for emergency use. Other sources of nitric acid are more costly and more cumbersome.

As to the source of the ammonia, it does not matter much from a technical point of view what source is used. In Europe, both the by-product ammonia from coal and the ammonia produced from cyanamide have been used. No doubt the synthetic ammonia of the Haber process is equally good. The ammonia, from whatever source, must be purified from sulphur and carbonic acid as in some of the contact processes, at least, these substances tend to poison the contact material, but small amounts of volatile organic substances are not harmful. The question is then, Is our present and our prospective supply of ammonia adequate for nitric acid manufacture in an emergency of war?

Statistics of By-Product Ammonia Supply

The distillation of coal in by-product coke ovens and in gas works in the United States produces to-day at maximum capacities, 88,500 tons of ammonia per annum. The increase in capacity which will be added to this during 1916 and 1917 by plants now under construction will be at least 38,000 tons. The Government's recent appropriation of \$20,000,000 if devoted

to an atmospheric fixation plant by the cyanamide process, and the necessary accompanying water power plant will have a capacity in ammonia equivalent, considerably less than this latter figure, i.e., less than the by-product ovens are adding to their capacity in two years. This is based on published estimates made in connection with the hearings on the nitrate bill.

The total capacity for by-product ammonia in this country will by the close of 1917 be at least 126,500 tons as NH_3 . This will be capable of producing 404,000 tons of 95 per cent nitric acid.

In Table 1 are arranged the by-product coke plants of the country with their coal consumption and ammonia producing capacities. Inasmuch as ammonia liquor is a more ready form for conversion into nitric acid than is ammonium sulphate, it may be noted that the coke plants of the country are so equipped that between 35 per cent and 40 per cent of their total ammonia capacity can be produced as liquor. It is to be borne in mind also that all plants producing sulphate produce about 25 per cent of their total ammonia in the intermediate stage of weak liquor and could quickly and easily be modified so as to place their product on the market as strong ammonia liquor, in that proportion.

By-product coke ovens can now produce a total of 75,950 tons of ammonia. Within eighteen months there will be about 38,000 tons added to this, or an increase of 50 per cent. The gas works of the country produce about 12,500 tons more, practically all in the form of liquor. The grand total of capacity at both gas works and coke ovens is 126,500 tons, of which somewhat over one-third is new, being added during the years 1916-1917.

If the United States consumption of ammonia for all purposes in 1915, viz., 70,000 tons, is subtracted from this increased total capacity and the balance, 56,500 tons—the surplus of 1918 capacity over 1915 consump-



FIG. 2—BY-PRODUCT COKE PLANTS IN THE UNITED STATES (SEPT. 1, 1916)

Plants indicated by circles with black in the center produce ammonium sulphate. Plants indicated by circles with white inside produce ammonia liquor. Scaled according to capacity.

tion—is then converted to nitric acid, it will produce 181,000 tons of 95 per cent acid or more than the estimated requirement for a war emergency. In addition to this a large amount of ammonia could, in the event of war, be temporarily diverted from its usual disposal as fertilizer.

The distribution of these coke oven ammonia plants over the country is a matter of large importance in connection with the problem of transportation to proposed plants using the ammonia. The map (Fig. 2) shows the location of these plants, with a rough indication of their size.

The Nitrogen Reserves

The reserves of minable coal in the United States are estimated by M. R. Campbell of the United States Geological Survey at 3540 billions of tons. Of this amount, by present methods of mining, probably 2360 billion tons can be brought to the surface. If the average nitrogen content in this coal is 1.3 per cent we have in our recoverable coal a reserve of nearly 31 billion tons of nitrogen. Part of this immense nitrogen reserve, unfortunately, is being wasted through the common methods of utilizing coal by combustion, and, by non-recovery coking. We mined bituminous coal in 1915 containing 6,000,000 tons of nitrogen, and of this 1,000,000 tons could have been recovered if all the coal had been treated in modern coke ovens or by-product gas producers. We actually recovered in by-product ammonia in 1915, about 51,000 tons of nitrogen.

About 9/10 of 1 per cent therefore of the coal nitrogen which was mined in 1915 was utilized. In 1918 possibly double that amount will be saved. Five per cent of what was mined would easily take care of the country's demands for ammonia and nitrates for many years.

The coal actually made into coke and gas in 1915 would have yielded 135,000 tons of nitrogen in the form of by-product ammonia if it had all been coked with by-product recovery. This would have approximately equalled the amount of fixed nitrogen actually used in the United States in 1915 other than that in the organic ammoniates such as packing-house wastes, and that in munitions sent abroad, that is, between 125,000 and 150,000 tons.

At the rate at which our coal is now being mined, the nitrogen reserves would be exhausted in 6000 years. Less than 10 per cent of the coal mined is being treated for recovery of its nitrogen and we have room therefore greatly to expand this recovery without increasing the rate of exhaustion of our reserves.

The coal by-product nitrogen, to be sure, cannot be practically recovered to any greater extent than conforms to proper utilization of the accompanying products, coke, tar, gas and gas-power. But this utilization is rapidly growing and even at the minimum rate of production and utilization of coke in this country in recent years, the corresponding fixed nitrogen recovery (say 125,000 tons), would amply provide for the country's needs in an emergency of war.

The Distribution of By-Product Ammonia in an Emergency of War

It is important to consider whether a sufficient amount of by-product ammonia can be spared from its regular channels of disposal to take care of the needs of a war emergency.

As has been shown above, the increase alone in by-product ammonia production in 1916-1917 will make more than enough nitric acid to supply war needs. If, however, it should be found necessary to use more than this in order to supply other demands for nitrates or

nitric acid there would be no hardship or difficulty in diverting, for the temporary need, a large part of the present production of ammonia from its normal uses.

Fertilizer, in America, is not indispensable for maintaining our home consumption of food crops. Let us not be misunderstood in this statement. The use of fertilizer is by all means to be encouraged. Far be it from anyone to depreciate the need of its increased use in this country. If we will improve our crop yields per acre and raise our efficiency in agriculture to a par with that of most other countries we must, among other things, use more fertilizer.

However, it can hardly be questioned that as a temporary expedient in an emergency of war, we could, without jeopardy to our food supply or the national welfare, divert 75 per cent of the 160,000 tons of ammonium sulphate now devoted annually to fertilizer purposes, and use it for nitric acid manufacture. Giving up also the 200,000 or 250,000 tons of nitrate used as fertilizer, we should still have available the abundant supply of organic ammoniates, tankage, bone, blood, cottonseed meal, etc., of which the consumption was about 2,000,000 tons in 1915.

The country's needs for refrigeration, which are stated authoritatively to be about 4000 tons of ammonia annually or under 5 per cent of the present ammonia-producing capacity, it is true, could not be diverted to other use, nor could the ammonia devoted to ammonium nitrate in military explosives. These uses, however, are small as compared to that of ammonium sulphate as fertilizer, and would not need to be invaded in order to provide for nitric acid manufacture.

If 57,000 tons of ammonia should be used to meet the Government's estimated need of 180,000 tons of nitric acid, and say 30,000 tons more of ammonia for other nitric acid, there would still remain, of our 127,000 tons of by-product ammonia, a balance of 40,000 tons to meet the requirements of industries. In 1915 about 26,000 tons were used for purposes other than as fertilizer.

Prospect of Future Growth

The above-named facts and figures presented in behalf of by-product ammonia are based only on the assured capacity of existing plants and of those under construction. It has been shown that the needs of the country in fixed nitrogen in an emergency of war can be met with this assured ammonia capacity. The industry, however, may look forward to a still larger growth.

The total coke consumed in the United States in 1915 was about three times what was produced in by-product ovens. The estimated capacity of by-product ovens for the year 1918, as given in the accompanying table, based on plants now under construction, is probably less than 55 per cent of the total coke which will be made in that year. By-product coking therefore has room to grow—it can almost double the capacity shown by plants now built or building before it will meet the country's present requirement in coke.

The present coke requirements are destined also to grow. The growth of coke by-products recovery is not limited, as many have claimed, to the demands of the steel industry. The sale and use of "domestic coke," i.e., all coke used for fuel purposes other than metallurgical, is rapidly expanding in this country. An amount not far from 2,000,000 tons was sold in the United States in 1915 and records of recent years show an annual growth of sales in many communities of about 30 per cent.

Recovery of Ammonia by Gas Producers

By-product gas producers afford another source of ammonia from coal, supplementing the coke ovens and

gas retorts. These producers offer immense possibilities for the future, since they can utilize non-coking and inferior coals, lignites, and the coal wastes obtained in mining and in coal washing.

Their yield of ammonia per ton of coal is large, viz.,

15 to 18 lb. as NH_3 , and their gas can be utilized for power in gas engines. These producers have had a large development in recent years in Germany and England and it is claimed that very cheap power is being made by them.

TABLE I
BY PRODUCT COKE PLANTS IN THE UNITED STATES, SEPTEMBER, 1916
Their Capacities for Coal Consumption and Ammonia Production

Owner or Operator	Location	No. of Ovens	Kind of Ovens	ANNUAL CAPACITY (NET TONS)		
				Coal	Total Coke	Ammonia as NH_3
Allegheny By-Product Coke Co.	Glassport, Pa.	120	Otto	260,000	195,000	450
Cambria Steel Co.	Johnstown, Pa.	462	313 Otto, 92 Koppers, 27 Gas-Machinery	1,530,000	1,224,000	3,442
Carnegie Steel Co.	Farrell, Pa.	212	Otto	830,000	581,000	2,283
Dunbar Furnace Co.	Dunbar, Pa.	110	Semet-Solvay	248,000	180,000	682
Lehigh Coke Co.	S. Bethlehem, Pa.	321	Koppers	2,407,000	1,920,000	5,400
Lackawanna Iron & Steel Co.	Lebanon, Pa.	228	Otto	500,000	360,000	1,250
Pennsylvania Steel Co.	Lebanon, Pa.	90	Semet-Solvay	387,000	278,000	1,017
Pennsylvania Steel Co.	Steelton, Pa.	120	Semet-Solvay	516,000	371,500	1,354
Phila. Suburban Gas & Elec. Co.	Chester, Pa.	40	Semet-Solvay	125,000	87,500	313
Camden Coke Co.	Camden, N. J.	150	Otto	360,000	252,000	900
Empire Coal & Coke Co.	Geneva, N. Y.	46	Semet-Solvay	146,000	102,200	401
Lackawanna Iron & Steel Co.	Buffalo, N. Y.	469	188 Otto, 281 Rothberg	1,350,000	972,000	3,375
The Solvay Process Co.	Syracuse, N. Y.	56	Semet-Solvay	65,000	45,500	193
New England Gas & Coke Co.	Everett, Mass.	400	Otto	650,000	455,000	1,950
Maryland Steel Co.	Sparrows Point, Md.	120	Koppers	730,000	525,000	1,825
National Tube Co.	Benwood, W. Va.	120	Semet-Solvay	270,000	189,000	744
Norfolk Gas Light Co.	St. Louis, Mo.	56	Koppers	320,000	210,000	880
Minnesota Steel Co.	Duluth, Minn.	90	Koppers	600,000	450,000	1,500
Zenith Furnace Co.	Duluth, Minn.	65	Otto	160,000	112,000	440
Cleveland Furnace Co.	Cleveland, Ohio	100	Semet-Solvay	450,000	337,500	1,125
Republic Iron & Steel Co.	Youngstown, Ohio	143	Koppers	1,020,000	744,000	2,805
Youngstown Sheet & Tube Co.	Youngstown, Ohio	201	Koppers	1,300,000	918,000	3,573
Toledo Furnace Co.	Toledo, Ohio	91	Koppers	560,000	408,800	1,540
United Furnace Co.	Canton, Ohio	47	Koppers	280,000	201,400	770
Hamilton Otto Coke Co.	Hamilton, Ohio	100	Otto	100,000	168,000	720
Milwaukee Coke & Gas Co.	Milwaukee, Wis.	160	Semet-Solvay	732,000	519,000	2,191
Northwestern Iron Co.	Maryville, Wis.	36	Otto	160,000	115,200	400
Citizens Gas Co. (1)	Indianapolis, Ind.	41	Semet-Solvay	330,000	237,600	908
Citizens Gas Co. (2)	Indianapolis, Ind.	190	Otto	320,000	230,400	880
Illinois Steel Co.	Gary, Ind.	560	Koppers	3,600,000	2,880,000	7,650
Central Indiana Gas Co.	Muncie, Ind.	22	Klönne	40,000	28,000	100
Inland Steel Co.	Indiana Harbor, Ind.	86	Koppers	585,000	438,800	1,535
By-Products Coke Corporation	St. Chicago, Ill.	280	Semet-Solvay	1,300,000	975,000	3,575
North Shore Suburban Gas Co.	Waukegan, Ill.	13	Koppers	55,000	38,500	165
Coal Products Mfg. Co.	Joliet, Ill.	53	35 Koppers, 18 Wilputte	340,000	238,000	1,020
Illinois Steel Co.	Joliet, Ill.	280	Koppers	1,500,000	1,200,000	3,375
The Solvay Process Co.	Detroit, Mich.	175	Semet-Solvay	1,150,000	862,500	3,163
Michigan Alkali Co.	Wyandotte, Mich.	80	Otto	94,000	65,800	235
Kentucky Solvay Co.	Ashtland, Ky.	103	Semet-Solvay	800,000	600,000	2,400
Chattanooga Gas & Coal Pro. Co.	Chattanooga, Tenn.	12	Roberts	74,000	51,800	185
Woodward Iron Co.	Woodward, Ala.	170	Koppers	970,000	737,200	2,207
Mich. Coal I. & R. Co.	Fairfield, Ala.	280	Koppers	1,650,000	1,237,500	4,538
Tenn. Coal I. & R. Co.	Ensley, Ala.	240	Semet-Solvay	540,000	410,400	1,485
Central Iron & Coal Co.	Holt, Ala.	60	Semet-Solvay	290,000	220,400	800
Totals, completed plants		6756		29,827,000	22,479,400	75,950

PLANTS BUILDING

Owner or Operator	Location	No. of Ovens	Kind of Ovens	ANNUAL CAPACITY (NET TONS)		
				Coal	Total Coke	Ammonia as NH_3
Northwestern Iron Co. (2d Bat'y)	Maryville, Wis.	36	Otto	160,000	115,200	400
Carnegie Steel Co.	Clairton, Pa.	64	Koppers	3,960,000	2,851,000	10,890
Seaboard By-Product Coke Co.	Jersey City, N. J.	110	Koppers	681,000	510,700	1,874
Wickwire Steel Co.	Buffalo, N. Y.	60	Semet-Solvay	386,000	289,500	965
Bethlehem Steel Co. (3d, 4th, 5th and 6th Batteries)	Sparrows Pt., Md.	240	Koppers	1,500,000	1,125,000	3,750
La Belle Iron Works	Follansbee, W. Va.	91	Koppers	610,000	445,300	1,677
Minnesota By-Product Coke Co.	St. Paul, Minn.	65	Koppers	380,000	273,000	1,140
River Furnace Co.	Cleveland, Ohio	204	Koppers	1,300,000	919,000	3,575
Brier Hill Steel Co.	Youngstown, Ohio	80	Koppers	520,000	379,600	1,430
American Steel & Wire Co.	Cleveland, Ohio	180	Koppers	1,150,000	830,500	3,162
National Tube Co.	Lorain, Ohio	208	Koppers	1,320,000	963,600	3,630
Dover By-Product Coke Co.	Canal Dover, Ohio	24	Roberts	120,000	87,600	300
Inland Steel Co. (3d Battery)	Indiana Harbor, Ind.	41	Koppers	305,000	228,800	801
Indiana Coke & Gas Co.	Terre Haute, Ind.	30	Gas-Machinery	150,000	105,000	450
Gulf States Steel Co.	Grainfield, Va.	37	Koppers	230,000	171,800	575
Colorado Fuel & Iron Co.	Pueblo, Colo.	120	Koppers	720,000	518,400	2,160
Bethlehem Steel Co.	Steelton, Pa.	60	Koppers	375,000	270,000	1,031
Totals, plants building		2236		13,897,000	10,126,000	37,810
Totals, completed plants		6756		29,827,000	22,479,400	75,950
Grand totals, for all plants		8992		43,694,000	32,605,400	113,760

Annual capacity for ammonia at coke plants.

Annual capacity for ammonia at gas works.

Total annual capacity of coal carbonizing plants. 126,260
 Practical yield of 95 per cent nitric acid from this amount of ammonia (126,260 tons) 401,000 tons
 Total consumption ammonia in U. S. in 1915. 70,000 tons NH_3
 AMMONIA CAPACITY (AT CLOSE OF 1917) IN EXCESS OF THAT NECESSARY TO MAKE 180,000 TONS 95 PER CENT NITRIC ACID. 70,100 tons NH_3

Germany's Situation Compared to that of America

Germany, when the war began, had to provide for immense new supplies of fixed nitrogen. Chilean nitrate was cut off, by-product ammonia had reached almost its limit of production, (the coke consumption of the country being all from by-product ovens), and finally, to cope with the enemy blockade of foodstuffs, the soil had to have nitrogenous fertilizer in undiminished quantity. There was no recourse except atmospheric fixation. Germany met the situation and, by a remarkable development of fixation processes has in two years built up a nitrogen industry from about 22,000 tons a year to about 140,000 tons, not including by-product ammonia. All credit be given her for this achievement.

America, on the other hand, uses for food crops very little fertilizer and would be in no degree dependent on it for maintenance of food supply in war. In this country, also, unlike Germany, the production of by-product ammonia is capable of a very large increase without causing an over-production of coke since half of our coke or more is now made without by-product recovery. This increase in fact, is rapidly being accomplished at the present time.

America can spare her by-product ammonia, temporarily, from its use as fertilizer. Germany can not. Ammonium sulphate, or by-product ammonia, furnishes in America less than one-fourth of the total nitrogen used in fertilizers.

The fixation of atmospheric nitrogen will come sooner or later in America. It will be welcomed as a valuable supplementary source of fixed nitrogen independent of foreign importation. We shall have it established in fair competition with existing industries, when, without Government subsidy but with proper water power legislation, it shall find low enough power costs to enable it to make and sell fixed nitrogen products at a profit.

We have shown that the supply of fixed nitrogen in this country from coal by-products is great enough to take care of estimated war needs and the latter therefore, cannot be urged as an excuse for a Government subsidy to the atmospheric nitrogen fixation industry.

The Government's Action

Now what has been done by our last Congress on this question, and what is the possible effect of its action?

An appropriation was made of \$20,000,000 to build a nitrate plant to be owned and operated by the Government. The act making this provision is a military measure, Section 124 of H. R., 12766, "An Act to Increase the Efficiency of the Military Establishment of the United States." The plant may be operated in time of peace and sell its product. In other words it is a Government ownership project, which may result in Government competition with private enterprise in time of peace. In the face of the fact that we have already an adequate supply of ammonia for war needs, Congress has provided for an expensive establishment to insure such a supply, and opened the way for Government operation of this establishment as a competitor for private trade.

Here we must call attention to the fact that the by-product coking and gas industries afford our only source of benzol, toluol and coal tar products. The present capacity of these industries would not give the nation all the toluol it should have for war needs in the manufacture of explosives. In spite of the fact that Great Britain and France have large coal by-products industries and that the present large production of toluol in America is being in great measure sent abroad, the present abnormal market price which toluol commands in this country shows that the demand is far greater than the supply. So important to military pre-

paredness is a maximum supply of coke by-products that the Government should run no risk of a set back to this industry until all of the coke shall be made with by-product recovery.

If the Governmental authorities which now have the nitrate problem in hand shall so interpret and apply this legislation of Congress as to permit Governmental competition in time of peace with present producers of ammonia, the expansion of by-product coking in this country will be endangered. When by-products do not command good prices the American manufacturer does not easily turn from the simple bee hive coking to the more elaborate by-product ovens. Conservation and industrial advancement in America are involved seriously in the decision to be made.

It is claimed for this bill that its virtue lies in benefiting the farmer by lowering the cost of his fertilizer. The producer's price of nitrogenous fertilizer in this country has not been greater than in other countries. This can be verified by published quotations. The farmer has to pay more for his fertilizer in the United States than he does in Belgium or in Germany because of higher transportation costs and other factors over which the producer has no control. It is now proposed, however, by advocates of Governmental fertilizer manufacture, that the present producers of ammonia shall bear the burden of a reduction in cost to the farmer, place their prices below those of European countries, and thus allow the expansion of large and important industries, essential to the national welfare, to be retarded. Investigation is now being made by Governmental boards, to determine, before the nitrate plant is built what shall be the process to be used therein. These investigating boards are fully informed as to the large and growing supply of by-product ammonia and are making their inquiries accordingly.

Methods of Recovery of Fixed Nitrogen as a By-Product of Coal Carbonization

The ammonia carried in the gases from coke ovens or gas retorts is partly in combined form as chloride, sulphate, cyanide, etc., and partly free or loosely combined as carbonate, hydrosulphide, etc. Since the raw gases always contain water as a product of the decomposition of the coal, an aqueous condensate forms in the gas mains and the large gas coolers. This condensate carries a large part of the combined ammonia and some of the free. It is a weak solution of ammonia varying in strength generally from 0.2 to 1.0 per cent NH_3 . In all plants whether they make sulphate of ammonia by the "direct process" or ammonia liquor by washing the gas, this condensate in the mains and coolers is obtained, and constitutes 20-30 per cent of the total ammonia.

In the "direct process" for ammonia recovery, the gas after being freed from tar passes directly into sulphuric acid in lead-lined saturators, arranged for continuous operation. The Koppers direct process, by use of reheaters for the gas, maintains temperatures in the gas and in the saturator such that an excellent quality of well crystallized sulphate forms and the bath is kept at constant strength. Condensation in the saturator is effectually prevented.

At plants where all of the ammonia is made into liquor a gas washing system is used, whereby the gas is thoroughly washed with cold water in suitable scrubbing towers. These are either of the "bell" type consisting of a series of superimposed rings in each of which the gas passes from under a bell through circulating water or of the simpler "grid" type in which water flows downward in the tower over grids which offer large surface to the gas for the absorption of its ammonia. The

weak aqueous liquor thus produced is distilled and concentrated by steam in special column stills, continuously operated, and requiring very little operating labor. The so-called "lime leg" takes the residue from the free ammonia still, and distills it with milk of lime.

For making purified liquor or aqua ammonia these stills are elaborated by the addition of more rings and dephlegmating sections; hydrogen sulphide and carbonic acid are eliminated by utilizing the great difference of solubility between these gases and ammonia gas in water or weak ammonia solution. Pyridene and traces of organic matter or of tars are removed by oil or charcoal washers. In some plants the last traces of Co, and S are removed by lime or alkali washers.

Aqua ammonia is being made at a number of plants in the United States by this continuous distillation method, so as to be practically free of carbonic acid and hydrogen sulphide. The costs of purification in this manner are low.

By-Product Ammonia for Nitric Acid Manufacture

Now, in case a question may be raised as to the suitability of by-product ammonia for use in a contact process of nitric acid manufacture, I will merely say that many evidences are at hand to show that this ammonia has been used successfully abroad for such processes on a commercial scale, and preliminary experiments in this country on a small scale show that the process works well with by-product ammonia and gives a conversion of 90 per cent or higher.

An article by Schüpphaus in "Metall und Erz," Vol. 13 (1916), p. 21, describes the practical operation of a plant making nitric acid by the Ostwald process and using crude ammonia liquor for the raw material. No difficulties likely to arise with this raw material are mentioned.*

Hilgenstock, a high authority on ammonia and its production, published an article in the German "Journal für Gasbeleuchtung," Nov. 27, 1915, on the methods of concentrating and purifying ammonia liquor from gas and coke plants. He states, "On account of the large demands of the war operations for ammonia, this production of concentrated liquor and of pure aqua ammonia has lately come to the forefront again."

A prospectus issued in 1913 by the English "Nitrogen Products and Carbide Co., Ltd.," and abstracted in *Iron & Coal Trades Review*, Vol. 86 (1913), page 837, states that in the contact process which they will use to make nitric acid from ammonia "it does not matter much from a technical point of view what source is used for the supply of ammonia." . . . "The ammonia plant . . . sends out nearly pure, dry, ammonia gas freed from CO₂ and H₂S. The gas is not freed from traces of organic materials which may come over with it for these impurities have been shown to exert no harmful influences on the process."

Further references of this kind showing the use of by-product ammonia in these processes might be cited. There appears to be nothing in the technical literature showing that such use has been found impracticable. The process has not been placed on a commercial footing in the United States and is only in the experimental stage in this country.

H. Koppers Co.,
Pittsburgh, Pa.

Economizers.—The B. F. Sturtevant Company, Boston, Mass., has issued a new publication, Bulletin 222, describing economizers in the power plants of paper mills. The booklet contains several illustrations of installations of Sturtevant economizers in paper mills and a discussion of the value of this appliance.

New York Meeting of American Electrochemical Society

Report of Concluding Sessions

An account of the two first sessions of the meeting held by the American Electrochemical Society during the last days of September in New York City in conjunction with the Second National Exposition of Chemical Industries was given in our last issue (page 381). A report of the two concluding sessions follows:

Thursday Afternoon Session

The Thursday (Sept. 28) afternoon session, held at the Hotel Astor, was devoted to the reading and discussion of papers on electro-metallurgical subjects.

The Protection of Iron by Electroplating

The protection of iron by electroplating was the subject of a paper of Prof. OLIVER P. WATTS of the University of Wisconsin and Paul L. DeVerter. The results are given of a series of experiments carried out at the Laboratory of Applied Electrochemistry of the University of Wisconsin, to determine the porosity of electroplating on iron, and to determine the protection afforded by different metals. It was thought that the superior protection afforded to iron by electrogalvanizing indicated either that the zinc deposits were less porous than those of other metals, or that in the thickness used commercially all electrodeposits are porous, and that the protective action of zinc was due to its being electropositive to iron.

The experiments confirmed the view that the protection was due to galvanic action.

(1) It was found that thin electrodeposits of zinc, copper, nickel and brass are full of holes, and therefore only the first may be relied on to prevent rusting, unless deposits are made much heavier than is at present the rule.

(2) Deposits of nickel should exceed 0.0015 in. (0.038 mm.) in thickness in order to protect iron out of doors, and copper or brass plate should have three times this thickness. Even then it is a question how long such coatings will afford protection.

(3) For the protection by electroplating of iron which is to be exposed to the weather, zinc (or cadmium) is the only metal worthy of consideration.

(4) The experiments do not show that double coatings—zinc followed by copper or brass—are distinctly superior to a single heavy coating of the latter metals. If zinc is to be used advantageously, it should form the outer coating.

(5) The authors think it very desirable that some method be found for producing a uniform electroplate, free from the holes which were responsible for rusting in these experiments. Could such plating be done deposits of nickel, copper and brass would form a far more effective protection to iron than at present.

In the discussion which followed Mr. Hogaboom referred to conclusion (2) and said that his experience from practice is in accord with Watts' conclusions. The subject is of vital importance for the industry.

Dr. Hering spoke of pinholes. Suspended foreign particles in the solution may be carried over to the cathode and be deposited with the metal. This may often account for the pinholes. The use of a diaphragm might hold such foreign particles back. With respect to pickling, electrolytic pickling is better; the bottom of the pit is cleaned.

Dr. Cushman spoke of pinholes in templates.

Dr. Richards thought that protection depends largely on the smoothness of the work.

*The essential features of this article were published in this journal, April 15, 1916.—EDITOR.

Mr. Hogaboom said that rough work is better as the plated deposit sticks better.

Mr. Saunders said that all steel shells for the Allies are plated.

Mr. Hogaboom, referring again to pin holes, pointed out that the different constituents in steel, such as martensite, pearlite, etc., take on the plating deposit differently.

Atmospheric Corrosion of Commercial Sheet Iron

The paper by E. A. RICHARDSON of Warren, Ohio, and L. T. RICHARDSON of Madison, Wis., on "atmospheric corrosion of commercial sheet iron" was then read by title. It is published in full on page 450 of this issue. It elicited a very lively discussion.

Dr. Cushman disagreed strongly with the conclusion of the authors. He referred to very extended tests, made by him, of a thousand full-sized sheets made up in different ways and exposed to severe tests. He concludes that pure iron stands up better than copper-steel. He referred to Sir Hadfield's work and the recent symposium in London. It all depends what the test is like. Some ancient irons contain much phosphorus and no copper. He concluded that too little attention has been paid to the effect of gases in iron or steel on corrosion.

Mr. D. M. Buck also referred to tests extending over five or six years with several thousand sheets, but he does not agree with Dr. Cushman. His experience is that the addition of copper to pure irons, as well as to any good heat of steel, is beneficial. 0.04 Cu is a distinct benefit.

Dr. Cushman said he has under test sheets with as much as 1.5 per cent Cu, but he cannot find any improvement due to copper. He emphasized that when comparing the quality of various steels we ought to have some standard test; otherwise we don't get anywhere.

Mr. Aupperle said that on the basis of several years of experiments, it is hard to tell the difference between 0.3 and 0.03 per cent Cu as to stability. Aitchison of Sheffield University found that copper-steel did not stand up as well as ordinary steel. The speaker emphasized that Messrs. Richardson had not taken into account the gas content of the samples tested. The presence of much gas in the steel may counterbalance to a large extent other effects.

Dr. Fink insisted that what we need is three or four standard tests. Otherwise we cannot compare results.

Lead from Brine Leaches

The paper by CLARENCE E. SIMS and OLIVER C. RALSTON on the electrolytic recovery from brine leaches was next presented. It was published in full in our issue of Oct. 1, page 410.

Electrolytic Zinc Dust

The paper by H. J. MORGAN and O. C. RALSTON on electrolytic zinc dust which was the next paper on the program, is published in full on page 465 of this issue.

Electrolysis of Vanadium Salt Solutions

The electrolysis of aqueous solutions of vanadium salts was the subject of an extensive paper of Dr. S. FISCHER, JR.

The paper gives the results of investigations made to determine whether or not it were possible to obtain metallic vanadium from aqueous solutions of its salts, there being but few electrolytic processes for obtaining vanadium, and the literature on the subject being very scant.

A large number of experiments were made—in all 368—and it was found that metallic vanadium could not be obtained. The electrolyte of Cowper-Coles with which he claimed to have obtained the metal was in-

vestigated, but no metallic vanadium was obtained after making 55 experiments.

A series of 112 experiments were performed on electrolytes containing another salt besides the vanadium compound. In a majority of the tests made, a black film was formed on the cathode wherever platinum was used. This film showed no indication of the presence of vanadium.

After investigating a number of inorganic and organic acids as solvents for vanadic acid, it was found that none acted satisfactorily as electrolyte.

A large number of experiments on alkali vanadate electrolytes and the anode reaction were also made, giving deposits of vanadic oxide.

A series of 33 experiments was run on sodium metavanadate, which indicated that an oxidation took place at the anode, the anode product being orange red to brick red in color. Platinum hydride was formed on a platinum cathode. In the other experiments various other alkaline electrolytes were studied.

In discussing the results the author states that it is probable that the high heats of formation of vanadium salts and the great tendency to form vanadates prevent the reduction of the compounds to metallic vanadium. Chemically it is known that vanadium oxide is extremely hard to reduce, even in the electric furnace and by the Goldschmidt thermite process.

There is very little available information as to the heat of formation of vanadium salts, and thus the deductions to explain the non-deposition of vanadium from aqueous solutions are only theoretical.

Messrs. Mott, Fink, Frary, and Blum participated in the discussion and a very interesting contribution to the discussion was an account of experiments by W. E. Koerner on the electrolytic behavior of tungsten, which is reserved for a future issue.

Electrodeposition of Nickel

The electrodeposition of nickel was the subject of a paper of L. D. HAMMOND of the University of Wisconsin.

Nickel plating, although practised for fifty years, is still based on "cut and try" methods. This paper gives the results of experiments made on the corrosion of electrolytic nickel anodes, annealed nickel anodes, and cast nickel anodes in various electrolytes. The conditions necessary for the direct deposition of nickel on zinc were investigated and the effect of boric acid addition to the electrolyte was studied.

The results are summarized as follows:

A study of the corrosion of cast nickel, electrolytic nickel, and annealed electrolytic nickel anodes was made in the following electrolytes: nickel sulphate solution; nickel sulphate solution to which boric acid was added; nickel sulphate boric solution to which various amounts of nickel chloride were added. Measurements of the total polarization pressures and current efficiency tests of these three anodes in the electrolytes listed above were made.

A study was made of the conditions necessary for the direct electro-deposition of nickel on zinc, together with some of the electrolytes which have been proposed for this purpose. Nickel can be deposited directly on zinc from baths used to deposit nickel on more electro-negative metals by employing a higher initial current density than is used with the more electronegative metals. Nickel was deposited directly on zinc from an approximately half normal hydrochloric acid solution to which 120 gm. per liter of nickel sulphate were added. The beneficial action of sodium citrate in the baths for the direct nickeling of zinc was found to consist not in changing the potential of zinc but in decreasing the rate

of deposition by immersion. Sodium potassium tartrate and sodium malate have a similar action but they do not permit the use of as high a current density as the citrate bath. The use of pure nickel anodes and the use of nickel chloride to secure anode corrosion, instead of any other chloride, is advocated. The use of nickel sulphate in the electrolyte instead of nickel ammonium sulphate is advocated.

The function of boric acid in the electrolyte is not different from that of any other acid; it simply maintains a small concentration of acid which is necessary to secure a good deposit.

In the discussion which followed Mr. Hogaboom complained that the paper was not written intelligibly to the plater. He said that small percentages of copper in nickel cause black nickel. Dr. Fink urged the platers and the trade journals for platers to adopt the metric system. Dr. Leonard Waldo eulogized the life work of the late Starr Sperry.

Nickel Plating with Rotating Cathodes

A paper on "current efficiencies in nickel plating baths with rotating cathodes," by Professor FRANK C. MATHERS and E. G. STURDEVANT, of Indiana University, gave the results of experiments in nickel plating baths and showed that the impurities in the nickel salts are the cause of the low initial current yields with stationary cathodes and the still lower yields with rotating cathodes. The following points are brought out:

Free mineral acid can produce this lowering of the yields, but the neutralization of the baths by boiling with nickel hydroxide did not overcome the trouble.

The yields from baths electrolyzed continuously with rotating cathodes started low but reached values of about 97.6 per cent in 2, 4 and 5 hours respectively for baths of 100, 200 and 300 cc. made from commercial nickel salts. Similar baths made from purified salts gave yields of about 98 per cent for the first hour regardless of the volume. This shows that impurities produce all the lowering of the yields.

The yields with stationary and with rotating cathodes are approximately equal in all cases where the baths are sufficiently pure. Nitrate lowered the yields more than any other impurity that was tried. Ferric salts, ammonium citrate or ammonium acetate lowered the yields, but ferrous sulphate up to 2 per cent was almost without effect.

Free boric acid lowers the yields somewhat when present in quantities greater than 2 per cent.

In the discussion which followed Mr. Hogaboom said that nickel plating cannot be carried on like copper plating for refining purposes only.

Electrotyping

The last paper of this session was entitled "Preliminary Studies on the Deposition of Copper in Electrotyping Baths," the authors being W. BLUM, H. D. HOLLER and H. S. RAWSON of the Bureau of Standards. The work is not yet entirely finished and a more complete account will be published later as a technologic paper of the Bureau. The investigation was carried out at the suggestion of the Government Printing Office, and was conducted in co-operation with the International Association of Electrotypers.

The paper describes investigations of the tensile strength, ductility and microstructure of copper deposited from copper sulphate-sulphuric acid solutions, upon graphited wax molds, under various conditions of deposition. The convenient conditions for satisfactory operation of copper electrotyping baths as determined by the experiments are given as follows:

1. CONDITIONS FOR DEPOSITION

Although no extended service tests of electrotypes containing copper of known properties have been made, examination of satisfactory electrotypes, and conferences with practical electrotypers has resulted in the following tentative specification for copper for electrotypes, viz., a tensile strength of 2500 to 2800 kg./cm.² (35,000 to 40,000 lb./sq. in.), and an elongation of 20 to 30 per cent. For the production of such copper, the following conditions are recommended as being the most convenient for commercial practice.

A. Composition of solution. The solution should contain from 50 to 80 g./L. (7 to 11 oz./gal.) of sulphuric acid, and from 250 to 200 g./L. (34 to 27 oz./gal.) of copper sulphate. In other words, the total content of copper sulphate plus sulphuric acid should be about 300 g./L. This corresponds to a specific gravity of 1.18 (22 deg. Baumé).

B. The solution should be maintained between 25 deg. and 30 deg. C. (77 deg. and 86 deg. Fahr.), unless high current densities are used. If the current density is above 8 amp./dm.² (75 amp./sq. ft.), the temperature may be allowed to rise to 35 deg. C. (95 deg. Fahr.).

C. Current density. At low temperature current densities from 5 to 9 amp./dm.² (47 to 84 amp./sq. ft.) may be employed. At 35 deg. C. (95 deg. Fahr.) current densities from 8 to 10 amp./dm.² (75 to 93 amp./sq. ft.) are most satisfactory.

D. Agitation. The highest practicable degree of agitation should be employed, especially between the anodes and cathodes.

2. ANNEALING EFFECTS

It is probable that during the process of "backing up" the shells with molten type metal, the copper of the shells is heated to such a temperature that some annealing takes place. The extent to which this occurs, or its effect upon the wearing properties of the plates, is difficult to determine. Examination of a number of finished electrotype plates, some prepared from copper deposited under known conditions, indicates that any such annealing effect has not been sufficient to make any visible change in the microstructure, though it may have produced some change in the tensile properties.

Dr. Blum, in reading the paper, showed many interesting examples of electrotyping. The appearance of the plate is not as important as tensile strength. The most important effect is that of temperature on the tensile strength of the copper.

In the discussion which followed, Dr. Waldo considered the paper to be an important contribution to our knowledge of the subject. He urged that the amount of metal deposited per kilowatt-hour as function of the current density be included in all progress on electrotyping and plating. Messrs. Hogaboom, Frary, and Tyler also participated in the discussion.

Friday Session

The concluding session of the meeting was held on Friday morning, Sept. 29, also at the Hotel Astor.

Dry Cells

A paper on "Characteristics of Small Dry Cells," by C. F. BURGESS, of the Burgess Laboratories, Madison, Wis., was presented by Mr. W. B. Schulte.

The paper brought out the interesting fact that the demand for small dry cells is rapidly increasing, due to the increasing use of pocket flash-lights. The output of cells for these lights is several times the output of standard No. 6 dry cells. The development of high-efficiency, miniature tungsten lamps has aided greatly in the development of the flash-lights.

A large number of tests of small cells have been made by the Burgess Laboratories as an adjunct to manufacture. The standard method of capacity test consists in connecting an individual cell to a resistance coil of 4 ohms, and discharging continuously until the voltage drops to 0.5 volt. Another test called the "shelf-life test" (because it shows the ability of the battery to stand idle) is made by measuring the short-circuit flash which the cell gives when connected momentarily to an ammeter. This method was found to give the best means of determining deterioration within the cell. From a large number of laboratory tests on cells of different makes the desirable qualities given in Table I, have been determined.

TABLE I

Performance That Should be Expected from Good Quality of Cell	Capacity	Per Cent Monthly
Cell Dimension	Minutes	Deterioration
2.25 x 1.25 in. (57.2 x 38.8 mm.)	360	Under 4%
1.3125 x 0.9375 in. (46.1 x 23.8 mm.)	300	Under 6%
2.125 x 0.75 in. (54 x 19.1 mm.)	250	Under 8%
1.875 x 0.625 in. (47.7 x 15.9 mm.)	120	Under 10%
1.5625 x 0.5625 in. (39.7 x 14.3 mm.)	65	Under 12%
1.875 x 0.5625 in. (47.7 x 14.3 mm.)	70	Under 12%

At the conclusion of the paper Mr. Schulte emphasized the unfortunate loose form of advertising dry cells. Mr. Baldwin thought it was important to determine an exact end point of the test. Mr. Gillingham said it was hard to decide on the best test for dry cells; no rapid method is entirely satisfactory. Dr. Hering suggested the constant-wattage test as giving a very sharp end point. Mr. Schulte replied that the constant-wattage test alone is not satisfactory for testing cells for flash-light service. The cooling effect of the lamp leads increases rapidly with a slight drop in voltage.

Alkaline Storage Battery

A paper by L. C. TURNOCK of the Carnegie Institute of Technology of Pittsburgh discussed the effect of temperature upon the performance of the Edison storage battery. The storage battery finds service in climates where there are great differences in temperature between summer and winter and the effect of temperature changes on the battery is therefore important.

While the tests were carried out at twice the value of the recommended "normal" rate of charge and discharge, this fact is not thought to impair the general applicability of the results.

The results are summarized as follows:

The available current efficiency of the battery at charge and discharge rates twice the value of the recommended "normal" rates increases up to 50 deg. C. (122 deg. Fahr.), after which it begins to fall off rapidly with further increase in temperature.

The current efficiency on discharge is higher than on charge as evidenced by practically no gas evolution during discharge even at rates higher than "normal."

A more effective input into the battery is possible by keeping the temperature below 50 deg. C. (122 deg. Fahr.). The best electrical efficiency is obtained by charging at a low temperature and discharging at a higher temperature.

The operation of the battery at temperatures above 50 deg. C. (122 deg. Fahr.) is detrimental to the life of the battery. The capacity of the positive or nickel hydrate electrode may be restored by an overcharge at a low temperature. The capacity of the iron or negative electrode will continue to lose in capacity with operation at high temperatures and its lost capacity can not be restored with overcharging.

The presence of hydrogen peroxide in the electrolyte during the various states of charge of the battery may account for the low capacities experienced with the bat-

tery allowed to operate at high temperatures. On charge it functions as a reducing agent toward the positive electrode and has the effect of an oxidizing agent toward the negative electrode.

Another view explaining the low capacity of the positive and negative electrodes, and which the evidence so far obtained seems to support the more strongly, is as follows:

On charge the nickel peroxide (NiO_2) and nickelic oxide (Ni_2O_3) form a solid solution, in which the concentration of NiO in the equilibrium phase decreases with increase in temperature.

The highly active metallic iron of the charged negative plates is soluble in the electrolyte and the rate of solution increases with increase in temperature. Solution of the iron in the electrolyte results in a permanent loss of capacity.

It is dangerous to allow the battery to become overheated and stand even on open-circuit in a place that is not sufficiently ventilated, artificially or otherwise. Evolution of hydrogen and oxygen, in the proper proportion to form in themselves a highly explosive mixture, is evident at 50 deg. C. (122 deg. Fahr.) and the rate increases rapidly with increase of temperature.

Dr. Frary suggested the extension of the tests to low temperatures, as this is important for automobile service in winter.

High-Temperature Heat Developed During Electrolysis

The paper by Dr. CARL HERING on this subject is published in full on page 454 of this issue. In the discussion which followed Dr. Northrup complimented the author on his paper and suggested the use of solutions containing metals. Dr. Fink suggested the use of organic liquids in the welding experiments. Dr. Frary said the phenomenon described was known not only in aqueous solutions, but also in fused salts. Mr. Mott referred to Sir Humphrey Davy's work and said he had himself tried flame arcs in liquids.

Super-Refractory Materials for Incandescent Lighting

The "Possibilities of Developing Super-Refractory Materials for Incandescent Lighting," were discussed in a paper by Dr. F. A. FAHRENWALD of the Case School of Applied Science, Cleveland, Ohio. The author states that in the list of known elements there is not one that alone will prove a serious competitor of tungsten for lamp manufacturing purposes. In view of this, it is evident that any search for the desired material must deal with combinations of elements.

He states that there is no reason to believe that proper alloy research will not develop a material for refractory, electrical-resistance lighting elements which will be more efficient than pure tungsten.

He gives the following outline as covering the field of development:

1. A super-refractory inter-metallic compound.
2. A solid solution alloy of a refractory metal, possessing lower vapor pressure than tungsten.
3. A refractory alloy having more favorable radiation characteristics than has pure tungsten.

In the discussion which followed, Mr. Mott said he had tested a great many materials in the flame arc. The determination of the melting point of vanadium is difficult. The presence of either carbon or oxygen increases the melting point. ThO_2 has the highest boiling point of any known substance. Messrs. Lloyd, Fink, and Hering also participated in the discussion.

Radium Emanation

A paper by HERMAN SCHLUNDT, T. H. LEAMING and JULIUS UNDERWOOD, of the University of Missouri, gives a "comparison of the ionization currents due to equal

quantities of radium emanation in different types of electroscopes."

Three different types of electroscopes widely used for determining radium emanations were standardized with known quantities of radium emanation. The electrical constants of the instruments were determined and also the volumes and internal surface areas of the ionization chambers. From the combined data the ionization currents per curie of emanation at the time of maximum activity were computed both from direct measurements and by applying the formula originated by Duane and Laborde.

The three instruments used were the new electroscope designed by Dr. S. C. Lind of the U. S. Bureau of Mines, the Wolf quartz-fiber electroscope, and the Mache-Meyer fontactometer. The results are tabulated in the paper.

The experimental results show that the reduction factor in the formula of Duane and Laborde has specific values for ionization chambers of the dimensions used in the experiments. In order then to convert curies into e.s. units or Mache units a reduction factor must be determined for each of these instruments, and the same is true if one desires to translate activities expressed in electrostatic or Mache units into curies or gram-seconds of radium. The authors state that the custom of expressing activities of water and gas samples in terms of Mache units should be superseded entirely by stating directly the radium content or curies per liter.

Silver-Peroxyhydrate

A paper by MORTIMER J. BROWN described "a new method for the study of silver-peroxyhydrate." The investigation had been carried out at Cornell University.

When silver nitrate solution is electrolyzed between insoluble electrodes, silver is deposited at the cathode and silver peroxyhydrate at the anode, there being presumably a simultaneous formation of nitric acid at the anode.

Both solid deposits are crystalline, and they grow rapidly one toward the other in arborescent crystals. Because of this fact, there is no doubt that the anode product is a good electrical conductor. However, almost as soon as the electrolysis begins, the black crystals break away from the anode, are attacked by the nitric acid in solution and eventually go entirely into solution with liberation of gas.

After studying this electrolysis carefully and at considerable length in a variety of types of apparatus, transparent and opaque, the author became strongly of the opinion that so long as the peroxyhydrate remained in electrical contact with the anode it was not attacked by the nitric acid simultaneously formed. It therefore seemed possible to develop a type of apparatus which would permit of the quantitative electrolytic precipitation of the peroxyhydrate and the checking of its weight against the gain in copper coulometers in the same electric circuit. Previous investigators had used no apparatus specially adapted to the problem in hand, and it is highly probable that none of them had for purposes of analysis more than a part of the material originally deposited, much of it having been lost by being dissolved in the electrolyte. This one supposition held the possible explanation for discrepancies between the analyses and conclusions of different men. Special apparatus was therefore developed.

The general results of the experiments are as follows:

Solutions containing 5 per cent and 20 per cent silver nitrate were electrolyzed with various current strengths. The silver content of the anode deposits averaged 79.37 per cent Ag, the limits being 79.03 and 78.2. The ratio of the anode deposit to copper precipi-

tated in the coulometer varied from 2.98 to 2.69. No pure oxide and no hydrated oxide can give both the observed silver content and the observed coulometer ratio. The calculated values for $(\text{Ag}_2\text{O})_x\text{AgNO}_3$ are 79.9 per cent and 2.97, while the values found for electrolysis of 20 per cent AgNO_3 and a current of 0.20-0.25 amp. are 79.3 per cent and 2.96; with 5 per cent AgNO_3 the corresponding values are 79.4 per cent and 2.75. The anode deposit is therefore impure $(\text{Ag}_2\text{O})_x\text{AgNO}_3$. The low value for the silver content may be due in part to occluded mother liquor or adsorbed silver nitrate; but this would raise the coulometer ratio and therefore cannot be the sole factor. The low coulometer ratio may be due to the presence of some substance like $(\text{Ag}_2\text{O})_x\text{H}_2\text{O}$ or $\text{Ag}_2\text{O}\cdot\text{AgNO}_3$. There is nothing in the experiments to show what the admixture is or in what form it is present. The low coulometer ratio may also be due to the anode deposit being dissolved by the solution. Special experiments are needed to determine this point.

It requires ten faradays to precipitate one gram molecular weight of $(\text{Ag}_2\text{O})_x\text{AgNO}_3$. These experiments confirm the conclusions of Mulder, Tanatar, Sulc, and Watson; they are in agreement with the experimental data of Baborovsky and Kuzma, though not with their conclusions. There is no real contradiction with the data of Luther and Pokorny, because these latter are admittedly not accurate enough to warrant any conclusion beyond the one that the peroxyhydrate contains a higher oxide than Ag_2O . Experiments should be made to determine under what conditions silver nitrate splits off from the peroxyhydrate.

Equilibrium between Bromine and Potassium Bromide Solutions

The equilibrium between bromine and potassium bromide solutions at zero degree C. was discussed in a paper by GRINNELL JONES and M. L. HARTMANN, of Harvard University.

The authors of this paper have recently published a study of the influence of temperature on the free energy of formation of silver iodide, a study which revealed suggestive relationships between the thermodynamic properties of this substance, and which furnished a plausible explanation of the negative coefficient of expansion of silver iodide. Since it seemed desirable to test the generality of these relationships by a study of other similar cases, a study of silver bromide was planned. But in order to interpret measurements of the potential of the silver-silver bromide-bromine cell similar to the silver-silver iodide-iodine cells previously investigated, it is first necessary to ascertain the concentration of each of the ions present (Br^- , Br_2 , Br_3^- , H^+ , K^+), and to ascertain also the mobility of each ion. And moreover, since the temperature coefficient of the free energy is concerned these data at two or more temperatures are needed, preferably 25 deg. and 0 deg. C. This paper records and interprets the results of experimental investigations of this preliminary problem at 0 deg.

Computations based upon the results show that the following reactions occur, and that a quantitative interpretation may be secured without the necessity of assuming that any other reactions occur:

1. Bromine dissolves as Br_2 .
2. $\text{Br}_2 + \text{H}_2\text{O} \rightleftharpoons \text{H}^+ + \text{Br}^- + \text{HBrO}$.
3. $\text{KBr} + \text{Br}_2 \rightleftharpoons \text{KBr}_3$.
4. $\text{KBr} + 2\text{Br}_2 \rightleftharpoons \text{KBr}_4$.

A saturated solution of bromine in water at 0 deg. has the composition: Br_2 0.2539 moles per liter; H^+ 0.001085; Br^- 0.000126; Br_3^- 0.000628; Br_4^- 0.000331.

The hydrolysis constant,

$$K_H = \frac{(H)(Br)HBrO}{Br_2} = 5.7 \times 10^{-11}$$

The equilibrium constant, $K_1 = \frac{Br \times Br_2}{Br_3} = 0.051$.

The equilibrium constant $K_2 = \frac{Br + Br_2}{Br_3} = 0.0246$.

The distribution coefficient of Br_2 between water and carbon tetrachloride (after correcting for hydrolysis) is, $D = 21.018 + 2.831 C$, where C is concentration of Br_2 in the carbon tetrachloride.

By the aid of these constants the concentration of each ion may be computed in any solution containing known amounts of potassium bromide up to 0.1n, and known amounts of bromine up to saturation.

The conductivity of a series of potassium bromide solutions from 0.001n to 0.1n has been determined at 0 deg. C. These results when extrapolated to infinite dilution by the method of A. A. Noyes give 83.8 for the mobility of potassium bromide, and if the value for the mobility of the potassium ion is 40.1, the mobility of the bromide ion is 43.7. From the data for the specific conductivity of solutions containing bromine we conclude that the mobility of the tribromide ion is 23.5, and of the penta-bromide ion, 16.3.

Industrial Conferences on Alcohol and Motor Fuels

Two interesting conferences, one on "Alcohol, Acetone, and Acetic Acid," and one on "Oils and Motor Fuels," were held under the auspices of the American Chemical Society during its recent New York meeting at the Chemists' Club on Thursday and Saturday afternoons, respectively. An account of these conferences follows:

ALCOHOL, ACETONE AND ACETIC ACID

At the conference held Thursday afternoon at the Chemists' Club, the subjects of industrial alcohol, acetone and acetic were discussed. Dr. ARTHUR D. LITTLE presided. It was predicted that cheap alcohol would find its largest use as a motor fuel. Sawdust was mentioned as a source which offers great possibilities. Black strap molasses, wood waste and waste sulphite liquor and other products were also discussed.

Dr. Little said that the potato distilleries are located in Europe, mostly in Germany. The grain distilleries are mostly in this country, in the Middle Western States, and the molasses distilleries along the southern and eastern coast. Alcohol from wood waste is produced only at Georgetown, S. C., and Fullerton, La., and from waste sulphite liquor at Mechanicsville, N. Y. He read a letter from J. Stuart Groves, who has been in charge of the plant of the du Pont Powder Company, making alcohol from yellow pine wood waste. According to this letter the process has been found very successful at this plant. Dr. Little thought the acetone production must be 10,000 tons per year at present, having been greatly stimulated by the war. Several processes were discussed, among which was an interesting development at the Shawinigan Falls Power Company, in Canada, where synthetic acetone is produced from calcium carbide by way of acetylene.

Dr. Matthewson, of the Shawinigan Falls Power Company, discussed the acetone process mentioned by Dr. Little. He said that a large plant is nearly finished and operations would be started on the manufacture of formalin, acetone and acetic acid in about three weeks. In the experimental work the chief difficulties were me-

chanical, especially in finding a material to stand sulphuric acid, and in the oxidation of formaldehyde with acetic acid. Oxygen was tried and found to be fairly successful, the danger of explosion being eliminated by proper regulation. By the first of the year it is expected that 10 to 15 tons of acetone per day will be turned out. Dr. Matthewson thought it doubtful whether the acetone process would pay under normal conditions, as there was an overproduction of acetone, but the other products could probably be made cheap enough to compete.

Dr. Little said there was a use for acetic anhydride which promises to become important, and that is in connection with the production of cellulose acetate which is finding increasing use in explosives, varnishes, auto goggles, artificial silk, and motion picture films.

In reply to a question from Dr. Gibney, of the U. S. Ordnance Department, as to the quality of wood waste alcohol, Dr. Little said it was perfectly feasible to produce a 95 per cent alcohol of the grade of cologne spirits, from wood waste.

Dr. Kyrides said that synthetic rubber becomes a greater possibility with cheap alcohol and acetone. Mr. Breckler said he had been associated with the alcohol business for twelve years, and that he thought the molasses alcohol companies held the situation in their hands. He said the only hope for alcohol was from sulphite liquors, the unfortunate part being that it requires special skill and training. In reply to a question he said that with molasses at 4½ cents alcohol could probably be produced at 20 cents per wine gallon.

Dr. Little said there were two plants running under the Ewing and Tomlinson process, and that the one at Fullerton, La., was producing 2000 to 2500 gallons per day. He said the day of 25-cent alcohol was coming, and that it would be preferred to gasoline as a motor fuel.

A conference was held at the Chemists' Club Friday afternoon on "Medicinal Chemicals," at which Dr. HAROLD HIBBERT presided.

OILS AND MOTOR FUELS

On Saturday afternoon a conference was held on the above subject, at which Dr. RAYMOND F. BACON, of the Mellon Institute, presided. At this conference a closer co-operation between automobile manufacturers and the makers of petroleum products was thought to be the only solution of the gasoline shortage problem. It was agreed that products do not always run uniform, that methods of testing do not always show the availability for a certain purpose, and that standardization was necessary.

Dr. Bacon said there was a great need for flexibility in refining so that the product in greatest demand can be readily produced. He also advocated a closer co-operation between the auto manufacturers and the refiners of petroleum. He said kerosene is being used more and more in trucks, and the further development of this field offers great possibilities.

Dr. Walter F. Rittman said that the chemist must co-operate with the automobile engineer so that the most efficient motor may be developed. He warned against the use of "gasoline savers," as they are usually 90 per cent kerosene, and often contain explosives.

Dr. Maberry said there should be a line of individual investigation of motor oils and fuels carried out on a larger scale, and Dr. Conrad agreed that it was a great field for the universities and schools, also the Bureau of Standards.

Others who took part in the discussion were Messrs. Day, Salisbury, Kelley, Baker, Parish, Gray, Robbins, and Humphreys.

One Hundred and Thirteenth Meeting of the American Institute of Mining Engineers

Arizona, September, 1916

It is undoubtedly the first time in the history of the Institute that a meeting was conducted on the basis of the one in Arizona. The novelty consisted in traveling at night, thus covering long distances, and conducting the meeting proper at different points along the road. There is not a member of those that partook of the Arizonian hospitality who does not feel as if he were now thoroughly acquainted with the land of wonders and with its kind and jovial citizens.

Arizona has, within the last six years, undergone a development in the metallurgy of copper which is marvelous. While Arizona always was a copper-producing state and such properties as the Copper Queen and the Old Dominion have produced copper over an extended period of years, the improvements made in processes and in plant construction can be best shown by citing the development of, say, the Warren District, near Bisbee. From 1880 to 1885 this district produced 34,356,000 lb. of copper. The annual production of copper in 1890 was 9,000,000 lb., in 1900 it was 34,000,000 lb. and in 1910 it was approximately 135,000,000 lb. copper. The production for the year 1915 was 165,000,000 lb. copper, 10,000,000 lb. lead, 55,000 oz. of gold and 2,350,000 oz. of silver. Similar developments may be observed in the other districts. It was, therefore, with an extraordinary amount of interest that the disciples of the mining and metallurgical industries, not alone of the United States, but also from Canada and Mexico, congregated at El Paso and turned their wondering eyes towards Arizona.

The interest taken in this meeting is best shown by giving a list of the members who participated on this trip.

L. M. Allen, Globe, Ariz.; C. J. Ambrose, Hayden, Ariz.; F. T. Anderson, El Paso, Tex.; J. E. Arnold, Miami, Ariz.; J. Owen Ambler, Douglas, Ariz.; George D. Barron, Rye, N. Y.; Mrs. George D. Barron, Rye, N. Y.; Percy E. Barbour, New York, N. Y.; A. D. Beers, New York, N. Y.; P. G. Beckett, Globe, Ariz.; I. H. Barkdoll, Globe, Ariz.; L. A. Blackner, Ray, Ariz.; A. L. Blomfield, Denver, Col.; F. C. Blickensderfer, Bisbee, Ariz.; W. B. Boggs, New York, N. Y.; Mrs. M. Bookman, St. Louis, Mo.; R. R. Boyd, Globe, Ariz.; S. D. Bridge, Comfort, Tex.; C. J. Briggs, El Paso, Tex.; W. L. Bradt, Saginaw, Mich.; J. F. Brown, Goldfield, Nev.; W. C. Browning, Superior, Ariz.; D. W. Brunton, Denver, Col.; H. P. Bowen, Miami, Ariz.; H. A. Buehler, St. Louis, Mo.; Edward E. Bugge, Boston, Mass.; J. A. Bjore, Globe, Ariz.; W. Burns, Morenci, Ariz.; G. M. Colvocoresses, Humboldt, Ariz.; K. P. Campbell, Saco, Ariz.; Will L. Clark, Jerome, Ariz.; Charles A. Chase, Denver, Col.; Carl H. Cole, David Cole, El Paso, Tex.; Mrs. David Cole, El Paso, Tex.; Norman C. Carraiche, Miami, Ariz.; F. C. Cottrell, Washington, D. C.; Ben H. Cody, Clifton, Ariz.; H. Cooper, El Paso, Tex.; W. M. Claypool, W. B. Cramer, Globe, Ariz.; Arthur Crowfoot, Morenci, Ariz.; Joseph F. Cullen, Midvale, Utah; G. H. Clossenger, Eagle, Ariz.; Cal. Gotsberger, Miami, Ariz.; D. H. Globe, Ariz.; S. H. Davis, Joplin, Mo.; Arthur C. Danian, Denver, Col.; Geo. C. Dewey, Selby, Cal.; Albert Doerr, South Pasadena, Cal.; R. G. Dufourcq, El Paso, Tex.; Kuno Doerr, El Paso, Tex.; B. Dolman, Ray, Ariz.; C. W. Parker, El Paso, Tex.; A. W. Dye, Douglas, Ariz.; E. G. Deane, Miami, Ariz.; H. I. Duncan, Globe, Ariz.; R. H. Dickson, Warren, Ariz.; W. M. Drury, El Paso, Tex.; Howard Eckfeldt, South Bethlehem, Pa.; Karl Eilers, New York, N. Y.; J. A. Ede, La Salle, Ill.; J. N. Ede, J. D. Ede, Fredonia, Ariz.; Superior, Ariz.; M. Elmsler, Los Angeles, Cal.; C. T. Emerich, Globe, Ariz.; M. J. Elising, Mrs. M. J. Elising, E. N. Englehardt, I. A. Ettinger, Superior, Ariz.; Robert Faulkner, Lebanon, Pa.; Percy LeR. Fearn, New York, N. Y.; Leon Fouquere, Warren, Ariz.; J. G. Flynn, Miami, Ariz.; Robert Franke, Miami, Ariz.; Siegfried Fischer, Jr., Golden, Col.; F. N. Flynn, Clifton, Ariz.; Paul R. Forbes, W. I. Garms, Hayden, Ariz.; Walter Garms, Ray, Ariz.; Wm. D. Gordon, El Paso, Tex.; J. C. Gray, Wenway, Warren, Ariz.; B. Britton Gotsberger, Miami, Ariz.; C. A. Grabbill, El Paso, Tex.; W. F. Geiger, Miami, Ariz.; R. J. Glendinning, Salt Lake City, Utah; Alden D. Goff, New York, N. Y.; W. B. Gohring, Warren, Ariz.; W. E. Gaby, Butte, Mont.; Walter Gross, Perth Amboy, N. J.; C. W. Goodrich, Butte, Mont.; Justice Gragan, New York, N. Y.; R. Dawson Hall, New York, N. Y.; H. T. Hamilton, Macozari, Mex.; Walter Harris, Globe, Ariz.; Stewart Hazelwood, San Francisco, Cal.; Herbert E. Hamilton, El Paso, Tex.; A. M. Hamilton, Saco, Ariz.; James W.

Hamilton, El Paso, Tex.; R. S. Handy, Kollodge, Idaho; E. Harms, Torreon, Mexico; Jas. L. Head, Warren, Ariz.; E. N. Hobart, Nogales, Ariz.; F. W. Hear, Globe, Ariz.; J. H. Hensley, Jr., Miami, Ariz.; L. O. Howard, Globe, Ariz.; James W. Hambleton, El Paso, Tex.; G. W. Hay, A. B. Harde, Philadelphia, Pa.; Justin H. Haynes, Denver, Col.; H. O. Hammond, Roger W. Hay, Warren, Ariz.; Edward C. Hegeler, Danville, Ill.; Miss. Hegeler, Danville, Ill.; Julius W. Hegeler, Danville, Ill.; E. C. Hickman, East Helena, Mont.; P. G. Hills, Leadville, Col.; J. P. Hodgson, Bisbee, Ariz.; M. F. Hall, Clifton, Ariz.; Alexander Imhoff, Los Angeles, Cal.; T. J. Jenks, Wickenburg, Ariz.; Mrs. S. J. Jennings, Sidney J. Jennings, Miss Amy S. Jennings, Miss Mary A. Jennings, New York, N. Y.; Wm. Strickler Jones, Atlantic City, N. Y.; Frank E. Johnson, Salt Lake City, Utah; Ira B. Joralemon, Warren, Ariz.; G. W. Kays, Kingman, Ariz.; D. N. Kay, Ray, Ariz.; S. J. Kidder, Mogollon, N. M.; R. B. T. Kiliani, New York; K. L. Kithill, Tucson, Ariz.; Edward H. Koenig, Perth Amboy, N. J.; R. W. Kerns, Warren, Ariz.; A. S. Koeselmann, Cananea, Mex.; O. M. Kuchs, Tooele, Utah; C. R. Kuzell, Anaconda, Mont.; J. J. Kruttschnitt, Jr., Tucson, Ariz.; E. H. Laws, Salda, Col.; William Lennox, S. H. Levison, Hayden, Ariz.; John Langston, New York, N. Y.; C. Legrand, Douglas, Ariz.; A. G. McGregor, Bisbee, Ariz.; P. M. McHugh, Denver, Col.; F. W. MacLennan, Miami, Ariz.; Alan F. McCormack, El Paso, Tex.; R. M. McIntosh, Mrs. McIntosh, Lake Linden, Mich.; W. E. McCourt, St. Louis; Wm. T. MacDonald, Hayden, Ariz.; Ellwood V. Matlack, Jr., Webster Groves, Mo.; E. J. Matlack, Webster Groves, Mo.; E. F. Marble, Hayden, Ariz.; F. J. H. Merrill, Los Angeles, Cal.; Seely W. Mudd, Los Angeles, Cal.; E. P. Mathewson and wife, Anaconda, Mich.; J. F. Manning, Holok, Korea; E. M. Marshall, Greens, Ariz.; A. H. Means, Tucson, Ariz.; E. L. Merriks, Miami, Ariz.; Edwin W. Mills, Holok, Korea; Chas. A. Mitke, Bisbee, Ariz.; McHenry Mosier, Bisbee, Ariz.; H. W. Morse, Los Angeles, Cal.; Philip U. Moore, St. Louis, Mo.; Mosman, New York; C. M. C. W. Merrill, San Francisco, Cal.; H. T. Murray, Hayden, Ariz.; R. T. Murrill, Flat River, Mo.; Henry W. Nichols, Chicago, Ill.; H. L. Norton, Globe, Ariz.; Arthur Notman, Warren, Ariz.; T. H. O'Brien, Dawson, N. Mex.; J. J. Ormsbee, El Paso, Tex.; J. H. Payne, Bisbee, Ariz.; Mrs. J. H. Payne, Bisbee, Ariz.; H. D. Fallister, El Paso, Tex.; E. F. Felton, Basil Prescott, El Paso, Tex.; Wm. J. Quigly, El Paso, Tex.; O. C. Ralston, Bisbee, Ariz.; F. L. Ransom, Salt Lake City, Utah; William H. Rea, Pittsburgh, Pa.; Mrs. Wm. H. Rea, Pittsburgh, Pa.; Miss Rea, Pittsburgh, Pa.; C. E. Rhodes, Pasadena, Cal.; Miss Marion Rice, Schenectady, N. Y.; Luther V. Rice, Chicago, Ill.; Stuart L. Rawlings, San Francisco, Cal.; E. E. Reyer, El Paso, Tex.; Walter A. Richelsen, Cananea, Sonora, Mex.; Ezraab Rider, Bisbee, Ariz.; J. F. Robertson, Coniston, Ont.; G. H. Ruggles, Miami, Ariz.; E. M. Robinson, South Bethlehem, Pa.; A. E. Ring, Flat River, Mo.; E. W. Rouse, B. E. Russell, Ray, Arizona; L. D. Ricketts, Warren, Ariz.; Mrs. L. D. Ricketts, Warren, Ariz.; F. R. Ricketts, Douglas, Ariz.; Carl Scholz, Chicago, Ill.; E. M. Sawyer, Tyrone, N. M.; Gerald Sherman, Bisbee, Ariz.; H. R. Simpson, Los Angeles, Cal.; Paul Sterling, Wilkes-Barre, Pa.; Bradley Stoughton, New York, N. Y.; F. W. Solomon, Miami, Ariz.; K. M. Simpson, Los Angeles, Cal.; C. D. F. Schuchter, El Paso, Tex.; Bradley Stoughton, New York, N. Y.; Walter A. Schmidt, Los Angeles, Cal.; Mr. Francis S. Schimerks, E. G. Snedaker, Goldfield, Nev.; S. P. Sparks, E. G. Spilsbury, New York City; P. A. Steger, Miami, Ariz.; Howard D. Smith, San Francisco, Cal.; Paul Stein, El Paso, Tex.; E. D. Stewart, El Paso, Tex.; Roger Strobel, East Helena, Mont.; Wilmer C. Swarbley, Philadelphia, Pa.; B. B. Thayer, New York; John C. Taylor, Denver, Col.; Knox Taylor, High Bridge, N. Y.; Roscoe Tates, Tacoma, Wash.; O. J. Tuschka, Globe, Ariz.; R. E. Vening, Perth Amboy, N. J.; G. D. Van Arsdale, Arthur P. Watt, San Francisco, Cal.; J. H. Watkins, Washington, D. C.; Harry S. Ware, Anaconda, Mont.; J. R. Webster, Morenci, Ariz.; J. L. White, Humboldt, Ariz.; P. D. Wilson, Warren, Ariz.; J. R. Woodul, Mex.; Phillip Wiseman and Mrs. Wiseman, Los Angeles, Cal.; H. E. Williams, Mrs. H. E. Williams, Calumet, Mich.; A. J. Weinig, Telluride, Col.; C. L. Wolfe, El Paso, Tex.; J. S. Williams, R. E. Yersa, Miami, Ariz.; Wm. H. Yearlde, Jr.; H. M. Ziesmer, Bisbee, Ariz.

The institute members were received open-armed at El Paso. The various local committees did everything in their power to make the stay at El Paso as pleasant and lucrative as possible. The Toltec Club was at the members' disposal. Automobiles were provided for touring the city and the military camps. The El Paso smelter was visited and the evening was spent at a Mexican dinner with Mexican music.

September 18th at Santa Rita, N. M.

The opening day of the meeting proper was the 18th. On arriving at Santa Rita, N. M., the open pit mines of the Chino Copper Company were visited. Then a short trip was made to Hannover, N. M., to inspect the dry mill of the Empire Zinc Company.

The mill was designed and put in operation by L. G.

Rowand. The operation proper was started in June, 1916. The ore treated is hard dense sulphide with contact rock and lime stone-carrying sphalerite, galena and other sulphides. Practically all the minerals are more or less magnetic, with the exception of the limestone and the galena. The feed to the separating department is closely sized, giving eight sizes between 10 mesh and 150 mesh. Practically all material through 150 mesh is removed by the dust separator. Rowand-Wetherill magnetic separators are used and the various products obtained have the composition given in Table I.

TABLE I—AVERAGE MILL RESULTS ON ROWAND WETHERILL MAGNETIC SEPARATORS

	Per Cent of Feed	Approximate Assays—			
		Zn	Pb	Fe	Ins.
Feed	100	18	0.2	6	39
Pole 1, 2 c. o., 3 c. o.	44	5	tr.	8	51
Pole 2 and 3 (part)	9	10	0.1	5	46
Pole 3 (part) and 4, concentrate	24	40	0.1	..	..
Pole 5 and 6, concentrate	6	51	0.1	..	..
Tails	4	10	12	16	23
Dust	11	20	0.1	4	34
Loss	2	..	..	..	..

Certain of the products are stored and saved for further use. The average recovery of zinc in concentrate is 67 per cent.

On returning to Santa Rita, a barbecue was given in honor of the Institute members by the people of the town, which was enjoyed by all present. The afternoon was spent at the Mill of the Chino Copper Company at Hurley, N. M. The mill seems somewhat crowded, due to the fact that it was built to handle 5000 tons, while it is actually handling 9500 tons. In 1915 the mill of the Chino Copper Company produced 68,293,893 lb. of copper. The flotation process used at

the mill is rather complicated, sulphides, oxides, carbonates and even metallic copper being floated.

The day was terminated by an open-air dance.

September 19th at Douglas, Arizona

On arriving at Douglas the Reduction Works of the Copper Queen Consolidated Mining Company were visited. The special features of this plant are: the bedding system for ores and the entire making up of the charge before entering the furnaces; large dust chambers and the arrangement of the blowers in the power house, one blower being supplied for each furnace. The equipment of the plant consists of 10 blast furnaces, 3 reverberatory furnaces, 9 converter stands of the 12-ft. vertical type and 16 McDougall 18-ft. multiple-hearth roasters. The capacity of the plant is 4500 tons of charge per day. Fig. 1 represents the flow-sheet of the works and is self-explanatory.

Fig. 2 is the flow-sheet of the Smelter of the Calumet & Arizona Mining Company (p. 483). The striking feature of this plant is its cleanliness, giving a general idea of the efficiency of the plant. The Messiter system of bedding is employed, three beds of 7000 tons each for the blast furnace charge, three beds of 10,000 tons each for the roaster mixture and a coke storage pile between being used.

The roaster plant consists of twelve 21½-ft. Herreshoff air-cooled furnaces with six hearths. These furnaces are arranged in two rows of six units. The gases from these roasters pass through a longitudinal flue between the two rows of furnaces to a hollow-tile dust chamber 140 ft. long and from this to a stack 279 ft. high and 20 ft. in diameter. Four oil-fired reverberatory furnaces, 19 ft. x 100 ft., occupy the space between the blast fur-

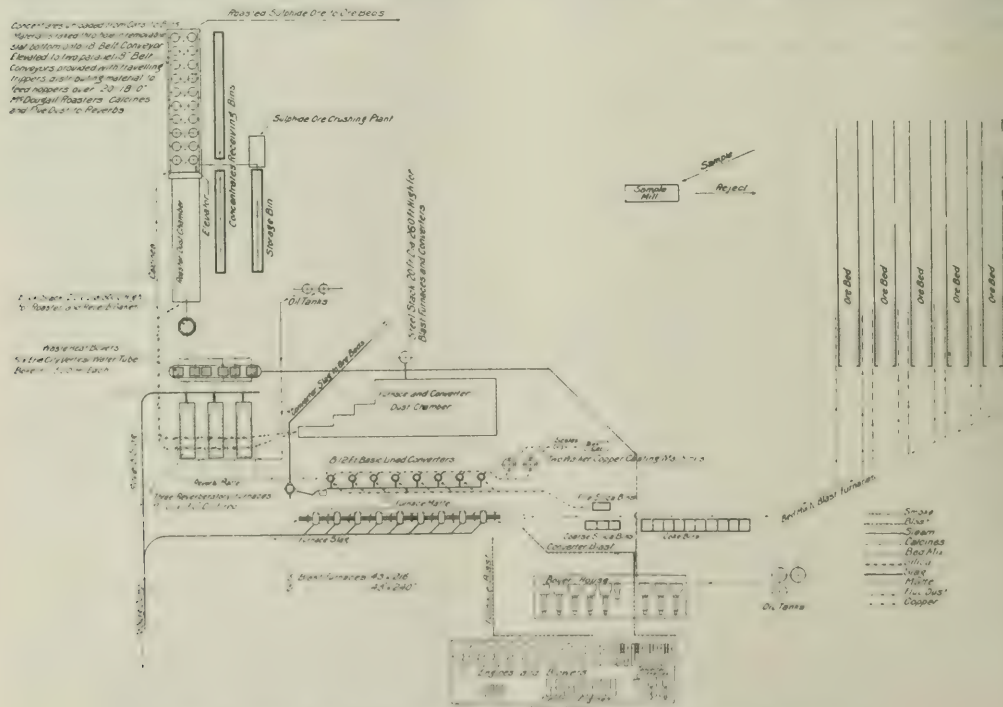


FIG. 1—FLOW SHEET OF THE COPPER QUEEN CONSOLIDATED MINING COMPANY

nace and the converter buildings. Three of these furnaces are in continual operation. The blast furnace department consists of two furnaces 40 ft. x 4 ft. at the tuyeres. The matte and slag overflow continually into settlers. The gases pass through uptakes to a chamber 180 ft. long and 2340 sq. ft. in cross-section and then to a brick-lined stack, which also takes care of the gases from the reverberatory plant. The converter building contains six stands with two extra shells of the Great Falls type basic-lined converters, 12 ft. in diameter, two 40-ton Morgan cranes, two 40-mold electrically-operated straight line casting machines and a McGregor skull breaker. The gases from the converters pass through a separate flue to a chimney 200 ft. high and 16 ft. in diameter.

Much new construction is under way, the main new

features being the increasing of the smelter capacity and a 200-ton chamber acid plant. The chamber acid produced will be used in connection with the leaching operation of the New Cornelia Copper Company at Ajo, Ariz.

Session on Smelting

The first technical session was held in the afternoon on smelting. The session was presided over by W. DOUGLAS. An address was made by President L. D. RICKETTS, followed by an address of welcome by J. C. GREENWAY. B. B. THAYER made the speech of thanks.

The first paper read was: *Features of the New Copper Smelting Plants in Arizona*, by A. G. MCGREGOR and B. S. WARREN. This paper has been printed in part in the Sept. 15 issue of this journal, pages 329 to

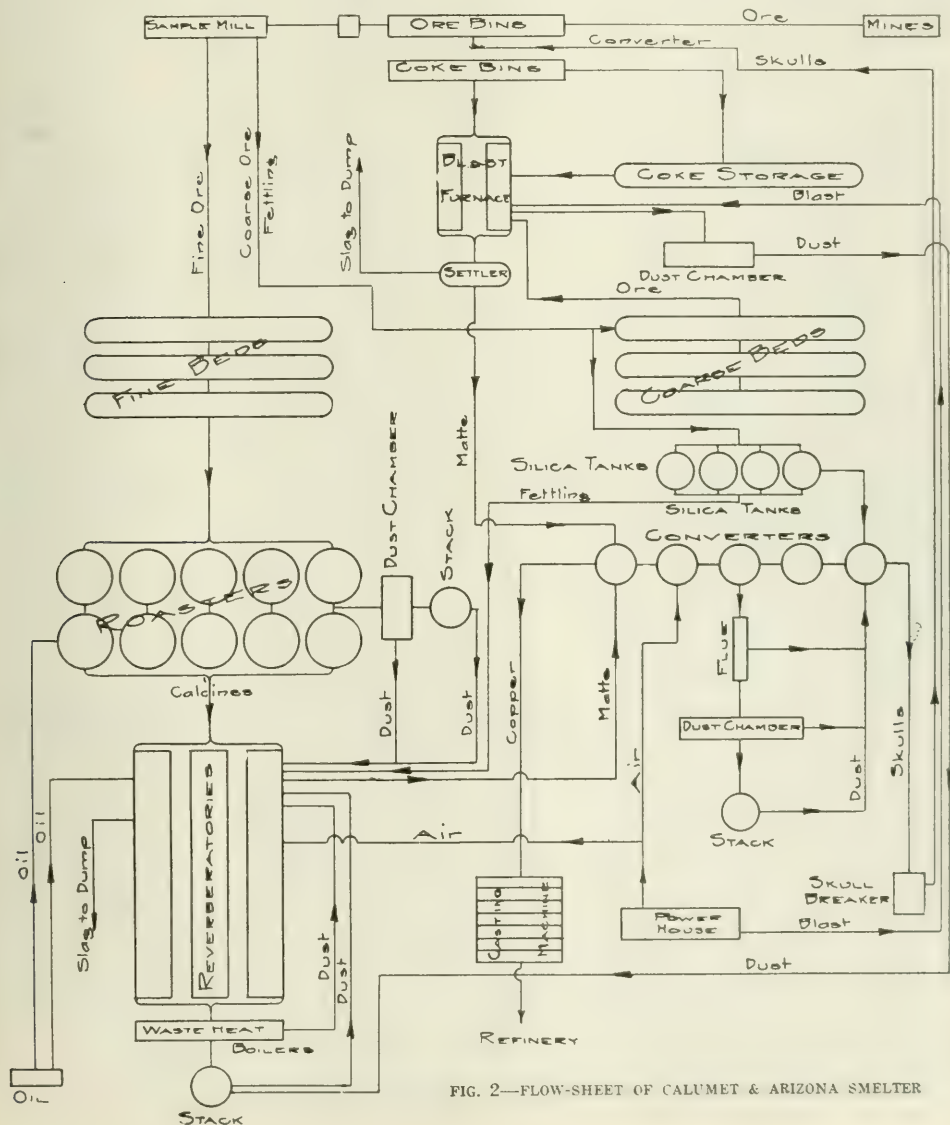


FIG. 2—FLOW-SHEET OF CALUMET & ARIZONA SMELTER

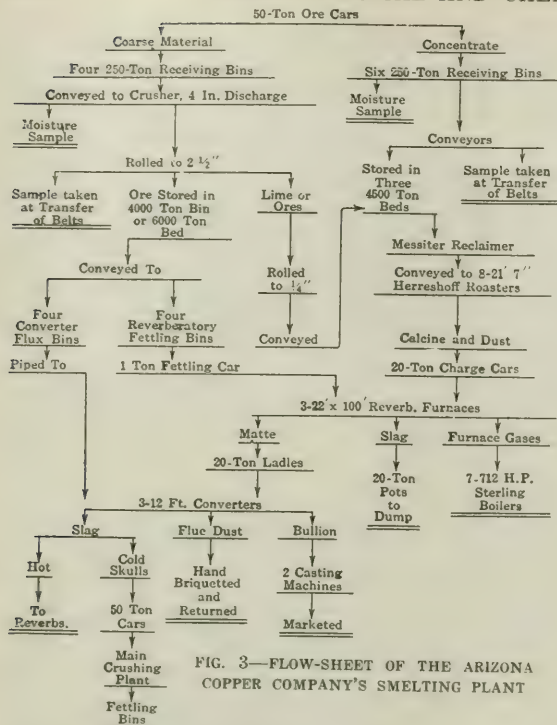


FIG. 3—FLOW-SHEET OF THE ARIZONA COPPER COMPANY'S SMELTING PLANT

337. The paper was discussed by W. DOUGLAS, L. D. RICKETTS and E. P. MATHEWSON.

The second paper read was entitled, *Smelting at the Arizona Copper Co.'s Works*, by F. N. FLYNN. The paper discusses in detail the construction and operation of the plant. Fig. 3 gives a flow-sheet of the smelter, which needs no further explanation.

The *Basic-Lined Converter in the Southwest* is the title of the paper by L. O. HOWARD, an extract of which was read by Bradley Stoughton. The paper deals essentially with the development of the use of the basic-lined converter in Arizona, giving at the same time operating-cost data. The paper was discussed by W. DOUGLAS, S. J. JENNINGS and E. P. MATHEWSON, the latter bringing out the point that it would be of great value to have comparative cost data between the vertical and the horizontal basic-lined converters.

The last paper read at this session was entitled *Determinations of Dust Losses at the Copper Queen Reduction Works*, by A. MOORE SAMUEL. It describes the methods and apparatus used for making the tests, and shows that such tests are not only essential, but economical to the general working of the plant. The fact is pointed out that dust determinations, no matter how conducted, are subject to many errors, and conclusions can only be correctly drawn from averages of a large number of tests conducted on the individual localities where dusting occurs. In this work, 10 per cent is allowed for probable errors, indicating the limited accuracy of the tests. The conclusions drawn from many experiments decided the engineers of this com-

pany to build two new flues. One of these will carry the roaster gases from the roaster dust chamber to the inlet end of the reverberatory chamber, and the other will carry the reverberatory gases from the header at the back of the boilers directly to the stack. In this manner the roaster gases will have an increased travel of 132 ft. at a low velocity, and will reduce the dust losses of the roasters considerably. The paper was discussed by W. DOUGLAS, L. D. RICKETTS, A. G. MCGREGOR, E. P. MATHEWSON, and S. J. JENNINGS.

Session on Leaching

The evening session on leaching was presided over by H. W. MORSE. The first paper read was: *Leaching Tests at New Cornelia*, by H. W. MORSE and E. A. TOBLEMAN. This paper deals essentially with the work done in the past year to determine finally the type of leaching plant to be installed.

The process decided on is briefly as follows: The ore is crushed to about 4-mesh; leached eight full days by counter current; washed with three to four counter-current wash waters; solutions practically neutral during last two days of contact with ore, is sent through reduction towers, where it meets sulphur dioxide in counter current. The ferric iron is thus reduced to below 0.4 per cent; then it goes to a revolving tumbler in which there is cement copper. There the ferric iron is still further reduced, and a corresponding amount of cement copper goes into solution. From the cement-copper tumbler the solution passes to a settling pond and then into the electrolytic cells, where a part of the copper is removed; then back into the leaching system, passing first through the oldest ore, which has already been leaching for seven days, and so on to begin the cycle again.

The flow-sheet of the 5000-ton leaching plant under construction is given in Fig. 4, and indicates clearly the individual steps of the process.

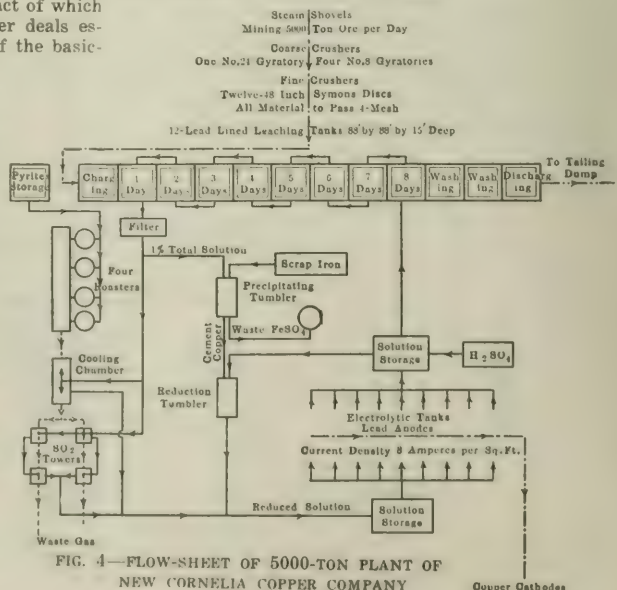


FIG. 4—FLOW-SHEET OF 5000-TON PLANT OF NEW CORNELIA COPPER COMPANY

Copper Cathodes

What may be expected from the large plant is briefly summarized as follows: The extraction of a 1.4 per cent ore, using closed wash cycle, is 82 per cent, and using an extra wash, 83 per cent; the acid consumption per pound of copper, figured on 100 per cent H_2SO_4 , is 3 lb.; the power efficiency in electrolysis, with lead anodes, is 1 kw.-hr. per pound of cathode copper; 0.5 lb. of sulphur is consumed per pound of cathode copper; it is only necessary for the neutral electrolyte to pass through the reducing tower; to control fouling of the electrolyte it is essential to pass about 1 per cent of the total solution volume over iron; approximately 12 per cent of the total copper will pass through the cement-copper side of the cycle, and finally the circulation of the electrolyte in the large plant will require a smaller volume than that obtained in the testing plant.

The discussion was led by LAWRENCE ADDICKS (communicated), G. D. VAN ARSDALE, S. J. JENNINGS, F. S. SCHIMERKA, and F. N. FLYNN. The main trend of the discussion was to prove that, given a fair trial, graphite anodes will bear up at least as well as lead anodes.

The second paper offered was: *2000-Ton Leaching Plant at Anaconda*, by FREDERICK LAIST and HAROLD W. ALDRICH. The paper was outlined by E. P. Mathewson. The material to be treated is accumulated tailings of the New Works dump, which amounts to about 20,000,000 tons, the copper and silver in the material amounting to approximately 0.64 per cent and 0.48 oz. per ton respectively. The dump is excavated by an electric hoist, and is loaded into 50-ton cars, which are hauled to the storage bins at the leaching plant. The storage bins hold 6000 tons and give a three days' supply.

From the bins the material goes to the 28 McDougall-type, six-hearth furnaces, each having a 20-ton feeder hopper, which are fed by belts. The furnaces are connected in four rows of seven each, and over each of the flues runs a gas flue, the four of which combine in a balloon flue with a downtake of 45 deg., which collects the dust and leads to the 200-ft. steel stack. The furnaces are air-cooled by means of blowers, the air intake being at the top of the furnace shaft and discharge being at the bottom, and leading to the leaching plant, where the hot air is used for heating purposes. Each furnace has a cooler 19 ft. long and 30 in. in diameter. The cooled concentrates enter a concrete-lined steel cylinder, which acts as a mixer, at the head end of which a very small stream of water is added to settle the dust. The moist calcines then are conveyed to the leaching house by means of an 18-in. conveyor.

The leaching plant contains ten circular redwood tanks 50 ft. in diameter and 14 ft. in height, the average charge per tank being 1000 tons of calcine. Above the ordinary slate filter bottom are two layers of heavy cocoa matting, and on top of this is a grating made of $1\frac{3}{4}$ by $3\frac{1}{2}$ -in. material so as to give 6-in.-square spaces. This grating fills up with calcine $3\frac{1}{2}$ in. in height, preventing the tearing of the matting by the sluicing waters. The tanks are in two rows of five each, and over each row passes a 20-in. belt conveyor with trip arrangements which dump the calcines into the distributors. Each tank has three lead pipes for the acid solutions and one iron one for water. Above each tank is a storage tank of iron for the 60 deg. Be. acid stock, which is fed to the solution as it enters the leaching vat. Sluice boxes at the bottom of the vats lead to launders which connect with the tailings launder. The solution tank building is a leanto to the leaching house, and contains five tanks 50 ft. in diameter and 14 ft. deep.

The precipitation of the copper and silver on scrap iron is done in specially designed concrete launders

250 ft. long and having a section of 4 by 8 ft. available for the iron.

Details of Operation.—The tailing is subjected to an oxidizing roast at approximately 500 deg. C. The calcines, after being cooled by a special system, are conveyed to the leaching house on belt conveyors. The leaching is accomplished by continuous downward percolation. The rate of percolation varies from 3 in. to 10 in. per hour for the first solution and the final wash water respectively. The operation is conducted between 40 deg. C. and 50 deg. C. To saturate a charge it requires approximately one-fourth of the weight of calcine in weight of solution.

The five tanks are divided as follows: One for each of the No. 1 and the No. 2 solution, one for the copper solution, and two for the wash water. After a tank is charged and leveled, 250 tons of No. 1 solution, containing 0.8 per cent Cu, 5 per cent H_2SO_4 , and 7 per cent NaCl is added. The solution drains through a drain at the bottom to the copper solution tank. The copper solution contains 1.9 per cent copper, 1 per cent H_2SO_4 , and 7 per cent NaCl. From the copper-solution tank the copper liquor flows through precipitation launders, where the copper and the silver are removed. Two-thirds of the solution from the launders goes back to No. 2 solution tank and the rest is discarded to prevent early fouling of solution system.

After all of the No. 1 solution has been added, and allowed to drain until none of it shows on the surface of the calcines, 1 per cent of the weight of the charge of salt is spread over the calcines. This is followed by 100 tons of No. 2 solution, but with enough H_2SO_4 to bring its strength up to 20 per cent acid. This is again followed by an addition of ordinary No. 2 solution. For a depth of 4 to 5 ft. a very strong chloride solution is traveling through the charge. As there is about 8 per cent ferrous and ferric iron in the solution, this forms ferric chloride, which is a strong corrosive reagent and enables the extraction of the silver, which otherwise would be only slightly attacked. Another benefit derived from the ferric chloride in the solution is that it will attack unroasted sulphide. The two No. 2 solutions, after draining, go to the No. 1 solution tank. The last addition of the No. 2 solution is followed by 300 tons of hot water. This wash water, minus a quantity sufficient to make up for the discarded solution, goes to the two wash-water tanks, the balance being conducted to the No. 2 tank. This latter makes up the amount of solution lost in the precipitation division. The precipitation of the values on the scrap iron needs no discussion. The wash-water composition is Cu: 0.2 per cent H_2SO_4 ; 1 per cent and NaCl: 1 per cent.

Results.—The blister copper produced carries about 70 per cent copper. The plant, during October, 1915, gave an extraction of 80 per cent of the copper and 60 per cent of the silver. The extraction is lower than the assays of the heads indicated, but various plant losses are somewhat high, especially that of the roaster department, where the dust losses amount to 4.5 per cent of the copper in the feed.

The paper was shortly discussed by F. N. FLYNN.

Possibilities in the Wet Treatment of Copper Concentrates, by LAWRENCE ADDICKS, was the last paper offered at this session. The article deals with experimental work conducted on Nacozari and Tyrone concentrates in an endeavor to find a commercial wet method for handling and treating concentrates in general. The topics covered experimentally are screen analysis, roasting, leaching, chloridizing the residues, and the recovery of the copper from solutions.

Large scale tests on roasting indicate the possibility

of obtaining high copper and low iron solubility. The residue after leaching, however, will contain sufficient copper to make further treatment necessary. Gold and silver also remain in the residues. The tyronite concentrates alone were subjected to large acid leaching tests. The acid consumption was found to be 2.28 lb. of 100 per cent H_2SO_4 per pound of copper. The leaching was conducted at 125 deg. F., with 5.6 per cent free acid in the liquor entering the trough. Generally, when a 15 per cent copper calcine is fed to the trough, the residue at the end of the trough will run 8 per cent copper, the extraction representing the instantaneously soluble copper. The residue may be brought down to 3.5 per cent copper by suitable agitation, with a consumption of a little over 2 lb. of acid per pound of copper, and with the extraction of a little iron. The final residue weighs only about 60 per cent of the original concentrate before roasting.

Various small scale experiments were tried on the chloridizing of the residues from the first leaching; 50 lb. were also sent to a plant where the Longmaid-Henderson process is in operation, and both tests gave satisfactory results. The liquor from the chloridizing plant would doubtless be reduced to argentiferous copper cement by iron, but 20 per cent of the original copper is involved. The sulphate liquor from the first leach could be precipitated on iron, or, with some limitations, would be suitable for electrolysis, regenerating the acid. It would seem possible to figure out a simple cementation plant, considering electrolysis as a competitor, on the basis of relative profit and not of necessity.

F. N. FLYNN, in discussing the paper, states that at Clifton experiments are being conducted to leach flotation concentrates without preliminary roasting, thus making the electrolyte directly.

The chairman then called for a *General Discussion on Leaching*. F. S. SCHIMERKA discussed the leaching of mill tailings at Clifton. MR. WILLIAMS of the Calumet & Hecla discussed the ammonia leaching process at the said plant, where a 40,000,000-ton dump is being leached by means of a solution containing ammonia and ammonium chloride. E. P. MATHEWSON, on being questioned by MR. VAN ARSDALE regarding wooden and concrete leaching tanks, stated that for small installations the wooden tanks are more economical than the concrete ones.

September 20th at Bisbee, Arizona

This day was dedicated mainly to Mining and Geology. The mines of the Warren District at Bisbee were inspected. Accommodations for surface, underground and geological trips were made. This district is one of the live wires of Arizona, producing in the neighborhood of 170,000,000 lb. of copper a year. The ore mined is treated at the Douglas smelters of the Calumet and Arizona and the Copper Queen Consolidated Mining Co., with small shipments of lead-gold-silver and high-sulphur-low-copper ores to the El Paso, Tex., Globe, Ariz., and Hayden, Ariz., plants of the American Smelting and Refining Company and

the International Smelting and Refining Co.'s plant at Miami, Ariz.

At the technical session on Mining and Geology, the following papers were read: "Geology of the Warren Mining District," by Y. Bonillas, J. B. Tenney and Leon Feuchere; "Comparative Friction Test of Two Types of Coal Mine Cars," by P. B. Liebermann; "Petrography of the Mount Morgan Mine, Queensland," by W. E. Gaby; "Stoping in the Calumet and Arizona Mines, Bisbee, Ariz.," by Philip D. Wilson; "Co-operative Effort in Mining," by Joseph P. Hodgson; and

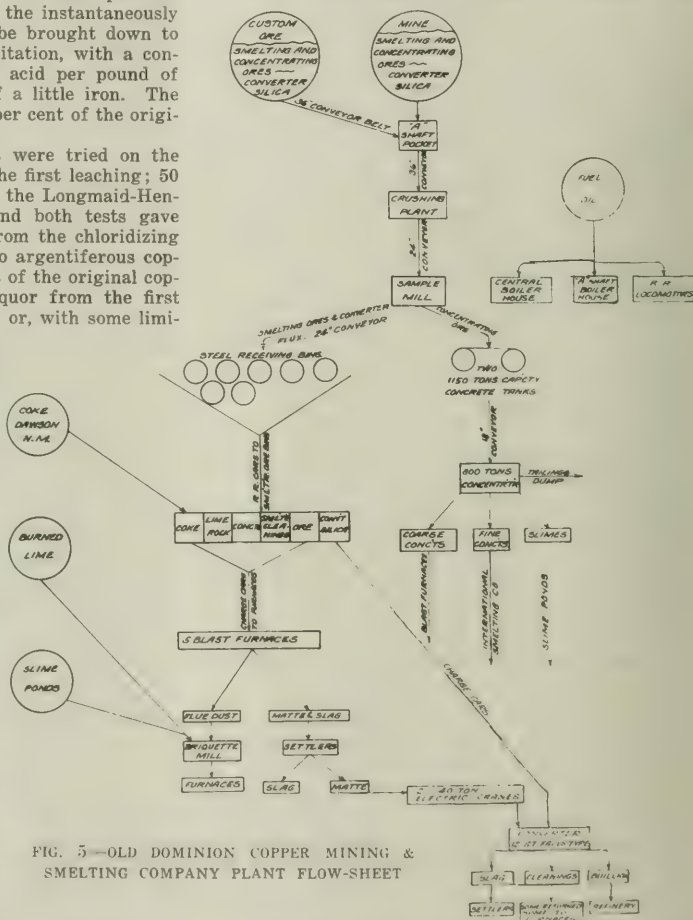


FIG. 5—OLD DOMINION COPPER MINING & SMELTING COMPANY PLANT FLOW-SHEET

"The Riffling of Diamond-Drill Cores," by W. R. Crane. The chairman of the session was G. F. G. Sherman.

A banquet was given to the members of the Institute at the Warren District Country Club, at which the following speeches were made: "Welcome to Arizona," by C. T. Knapp; "Arizona, Old and New," by L. D. Ricketts; "Arizona Present," by Walter Douglas; "The American Mining Congress," by Carl Scholz; "Why We Are Here," by Colonel Tillson, Twenty-second U. S. Infantry; and "Ave et Vale," by John Mason Ross. Philip N. Moore officiated as toastmaster.

September 21st at Globe

The first part of the schedule was to visit the Mines and Reduction Works of the Old Dominion

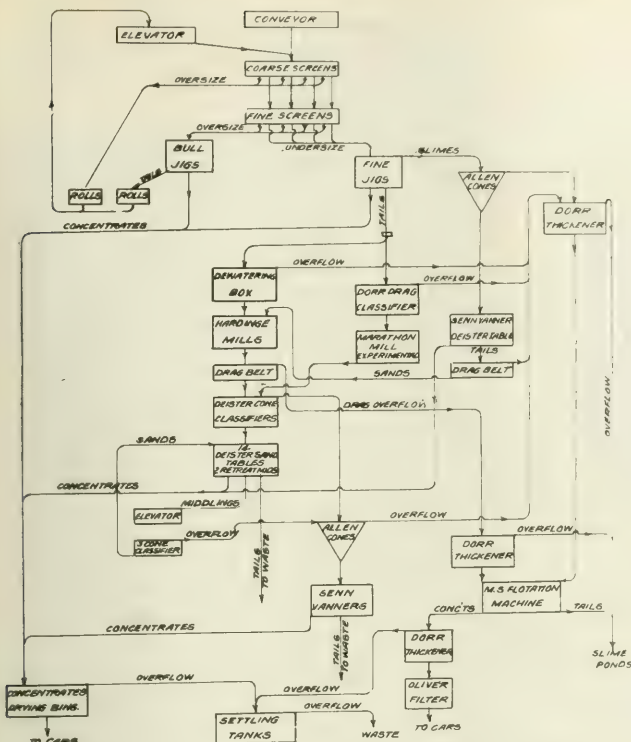


FIG. 6—OLD DOMINION COPPER MINING & SMELTING COMPANY
CONCENTRATOR FLOW-SHEET

Copper Company. Fig. 5 is the flow-sheet of the plant, and Fig. 6 that of the concentrator plant. The crushing plant consists of two No. 7½ gyratory crushers, one for smelting ore and one for concentrating ore; one 48-in. Symons disk crusher and two 36-in. Symons disk crushers; one 8 ft. x 5-ft. trommel and one 10 ft. x 5-ft. trommel, both having circular 1-in. holes. The sampling mill is of the Vezin type, 100 tons of ore yielding a sample of 16 lb.

The concentrator equipment consists of shaking screens, jigs, 3 Woodbury classifiers and jigs, two Traylor rolls 42 in. x 16 in., for coarse crushing, and five 8 ft. x 36-in. Hardinge pebble mills and one 8 ft. x 48-in. Marathon mill for fine crushing. The other machines used are Deister tables, Senn vanners, coarse concentrating vacuum tanks, and a Blaisdell excavator. The flotation plant contains 300-ton, 16-box mineral separation machine and two Oliver filters.

The smelter comprises one furnace 19 ft. 3 in. x 44 in. and four furnaces 16 ft. 6 in. x 44 in. The average tons charge per furnace per day is 282. The per cent coke to charge is 12.85. The average blast pressure is 21.5 oz., and the matte fall is 18.33 per cent. The converters used are of the 12-ft. Great Falls type. The arrangement of the smelter plant is clearly shown in Fig. 5.

Flotation and Concentration

The afternoon session was held on Flotation and Concentration. The acting chairman was W. J. MILLS. The first paper presented was that by DAVID COLE, entitled, *The Advent of Flotation in the Clifton-Morenci District, Arizona*. The article treats of the gradual development of the flotation process and the

use of the C-B flotation machines. The C-B flotation machine is a development of the simple tube-grate cell, of which Fig. 7 gives an illustration. Experimental work on this single cell was so satisfactory that it was decided to build a three-stage machine to have a capacity of 400 tons per day. After some mechanical changes, such as overcoming the corrosive action of the water and the clogging up of the air ducts, the machine was found to work satisfactorily on a large scale. A longitudinal section of the C-B flotation machine is given in Fig. 8. Tests were run between this new type of cell and the Callow cell, and it was found that it would handle much larger amounts of material. It also makes large volumes of very rich froth. The paper was not discussed.

The second paper on the program was *History of the Flotation Process at Inspiration*, by R. GAHL. This paper is printed in full in the September 15th issue and in the present issue of this journal. A lively discussion followed by Messrs. LAIST, SCHIMERKA, MORSE, COLE, HANDY, CAMPBELL, RICKETTS, COTTRELL and RUGGLES. Dr. GAHL first extended the paper to the present time, mentioning that oxidized copper and sulphides might be converted to carbonates and then these floated, but at present the method is not economical. Limestone may be used to precipitate soluble copper. Tailing middlings may be floated.

MR. LAIST communicated that the choice of a flotation machine depends upon where it is to be used. Pneumatic machines work better in an alkaline solution, while impeller type is better for acid solutions. The impeller machine requires an air supply; the machine for acid solutions requires an air supply. The impeller machine gives a tougher froth. Power factor is the main criterion for the selection of an impeller or pneumatic flotation machine.

MR. COLE wished to know if it were beneficial to remove the classifiers. DR. GAHL replied that the expense of operating a classifier is low, and it requires a small settling capacity for the table tailings, and the

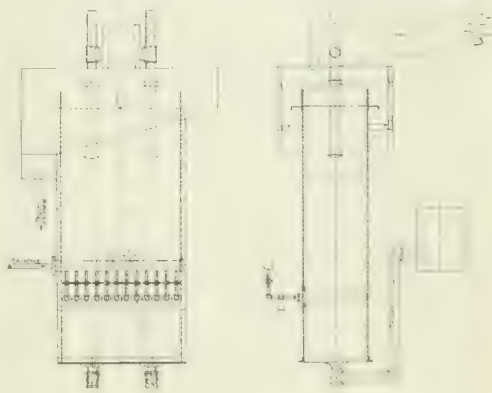


FIG. 7—SIMPLE TUBE-GRATE CELL

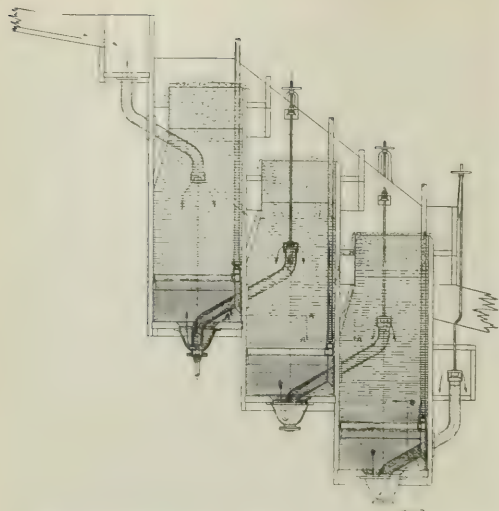


FIG. 8—LONGITUDINAL SECTION OF C-B FLOTATION MACHINE. THREE CELLS IN SERIES

water may be reclaimed at the foot of the mill at a low cost. Dr. Gahl believes that a hydraulic classifier pays for itself. MR. COLE asked whether it would be an advantage to avoid the separation of the sands and slimes. DR. GAHL replied that a better sand treatment is obtained by removing the sand first. E. P. MATHEWSON confirmed Dr. Gahl's statement.

In a communicated discussion of this paper by DAVID COLE of El Paso, Tex., published in the October "Bulletin" of the Institute, some interesting data are given on the milling problems which came up during the flotation experiments. Prior to the use of flotation the greatest problem was the reduction of the losses of sulphides in the slime. The Inspiration Company in 1912 began to study its milling problems, and plans were drawn for a 7000-ton per day gravity process plant. It was at this time that experiments on flotation promised to solve the slime problem. A "pilot" mill was built to treat 600 tons of ore per day, pending the completion of the milling plant. It was in this test mill that the flotation problems, grinding problems, power consumption, use of water, and many other questions were threshed out. The "pilot" mill paid for itself from the production which it turned out. Many different kinds of crushers, pulverizers and mills were tried out. The Marcy type of ball mill was finally adopted, although the conical type steel-ball mill vs. the Marcy type steel-ball mill did not receive a tryout, contrary to general opinion. Whether or not the Hardinge machine, when built as a ball mill with the required strength, type of lining, size of feed and discharge opening would do as well, was not determined, owing to the pressure of time.

The third paper on the topic of flotation was: *Some Miscellaneous Wood Oils for Flotation*, by R. C. PALMER, GLENN L. ALLEN and O. C. RALSTON. These oils were tested on three different ores: Ore A was from the Arthur Zinc Mining Co., near Ruby Valley, Nev., and consisted mainly of galena, sphalerite and quartz minerals. Ground quartz was mixed with this ore to make it sufficiently low grade. Ore B was the heavier sulphide ores from Cripple Creek, Colo., consisting of siliceous material, some pyrite, sylvanite, calaverite, and some other tellurium minerals. Ore C

was the milling ore of the Utah Copper Co., from the mine at Bingham, and essentially copper minerals such as chalcophyrite, cupriferous pyrite, etc. Each ore was subjected to an acid test, an alkaline test, and a test using neutral water.

The oils investigated were as follows: No. 23 was an authentic commercial pine oil, specific gravity 0.9385, and having a sulphonation residue of 0.8 per cent. No. 11 was a commercial wood oil obtained from the destructive distillation of maple and birch wood, having a specific gravity of 0.934 at 21 deg. C. No. 18 was hard wood tar obtained by the dry distillation of equal portions of beech, birch and maple wood. Its composition is 12 per cent pyroligneous acid, 8 per cent wood oil, 42 per cent wood creosote oil, and 38 per cent wood pitch. The specific gravity at 21 deg. C. was 1.067. No. 15 is the tar left on completely distilling off the pyroligneous acid of beech, birch and maple wood. The tarlike substance left is heavy, non-volatile and viscous, and has a specific gravity of approximately 1.4. It is 50 per cent soluble in water, the rest dissolving in the pyroligneous acid. No. 16 is a 15 per cent water solution of the water-soluble part of No. 15, and has a specific gravity of 1.061 at 21 deg. C.

TABLE II—TESTS ON ORE A IN NEUTRAL, ACID AND ALKALINE SOLUTIONS WITH DIFFERENT OILS

Analysis Head: Lead, 3.4 Per Cent, Zinc, 4.74 Per Cent

Oil No.	Character of Oil	Re-marks	Total Time, Min.	Total Oil, Lb. per Ton	Total Acid, Lb. per Ton	Total Alkali, Lb. per Ton	LEAD		ZINC	
							Per Cent	Per Cent Ex-traction	Per Cent	Per Cent Ex-traction
23	Pine oil	Concentrate tailing	10	0.375	.....	.....	55.9	53.1	12.4	62.2
			10	0.375	.....	.....	1.6	.....	0.3	2.3
			10	0.375	11.14	.....	32.3	87.9	37.9	78.2
			10	.....	3.36	.....	0.4	.....	1.1	.....
			15	0.375	.....	.....	8.0	89.5	25.5	79.1
11	Hardwood "wood oil"		17	1.11	.....	.....	57.2	92.6	20.4	58.2
			10	0.18	.....	.....	0.3	.....	0.4	.....
			16	0.94	3.68	.....	37.9	88.7	34.2	72.6
			15	0.17	3.68	.....	0.4	.....	1.4	.....
			5	1.29	.....	4.0	48.0	97.2	32.0	64.8
18	Crude hardwood "settled tar"		17	1.25	.....	.....	48.6	97.2	28.0	68.4
			3	.....	.....	.....	0.1	.....	1.2	.....
			19	1.24	3.68	.....	37.7	98.2	33.4	76.5
			6	.....	.....	.....	0.1	.....	1.2	.....
			4	1.70	.....	2.0	48.7	98.0	27.9	63.4
15	"Dissolved hardwood tar"		20	1.44	.....	.....	59.2	79.4	16.2	30.2
			7	.....	.....	.....	0.7	.....	3.5	.....
			15	1.44	5.52	.....	30.2	88.7	13.9	69.8
			10	0.72	3.68	.....	0.4	.....	1.9	.....
			20	1.44	.....	4.0	66.7	73.0	38.1	30.3
16	Water solution of No. 15		13	1.80	.....	.....	55.1	90.2	22.0	43.7
			5	.....	.....	.....	0.4	.....	2.9	.....
			10	1.80	7.36	.....	30.2	92.2	40.3	77.2
			4	.....	.....	.....	0.3	.....	1.2	.....
			19	1.80	.....	4.0	53.7	77.4	23.3	44.7
14	Crude hardwood pyroligneous acid		4	.....	.....	.....	0.8	.....	2.9	.....
			20	14.00	.....	.....	54.3	86.2	22.7	51.5
			3	.....	.....	.....	0.3	.....	1.5	.....
			15	14.00	5.5	.....	29.5	72.2	41.5	70.0
			5	.....	.....	.....	1.0	.....	1.5	.....
12	Tar-free hardwood pyroligneous acid		17	12.0	.....	.....	62.0	64.8	9.8	42.7
			6	.....	.....	.....	1.5	.....	3.4	.....
			20	14.00	.....	.....	54.3	86.2	22.7	51.5
			3	.....	.....	.....	0.3	.....	1.5	.....
			15	14.00	5.5	.....	29.5	72.2	41.5	70.0
10	Crude softwood pyroligneous acid		17	10.0	.....	.....	53.8	73.3	23.9	41.3
			13	4.75	.....	.....	1.0	.....	3.0	.....
			18	12.0	3.68	.....	31.6	64.7	35.2	67.3
			7	4.00	.....	.....	1.3	.....	2.2	.....
			12	16.00	.....	4.0	49.1	57.8	17.9	15.0

No cleaner test

No. 14 was a semi-commercial pyroligneous acid obtained from maple. Its specific gravity was 1.036 at 21 deg. C., and it had a composition of 9.7 per cent dissolved tar, 4.8 per cent wood alcohol, and 11.9 per cent acetic acid. No. 12 was a commercial pyroligneous acid obtained by distilling birch and maple, the tar having been removed by distillation. The specific gravity of this oil was 1.008 at 21 deg. C., and it contained 3.1 per cent wood alcohol and 5.9 per cent acetic acid. Oil No. 10 was commercial pyroligneous acid, obtained by the distillation of Southern yellow pine. Its specific gravity was 1.034 at 21 deg. C., and contained 1.8 per cent alcohol, 2.85 per cent acid, and 7 per cent dissolved tar.

The results obtained by the authors are best reproduced in the tabular form given by them, as the work is of practical significance. This is done in Tables II, III, IV, V.

The last paper read was the one by Frederick Laist and Albert E. Wiggins, entitled: *Flotation Concentration at Anaconda, Mont.* Part I covers all the experimental work comprising tests with standard Minerals Separation machines, tests with mineral separation machines of the sub-aeration type and tests with the Callow pneumatic machine. Tests on various kerosene sludge acid oils and creosote oils were made and the blankets for the Callow cell were tested. It was concluded that the Minerals Separation machine was best adapted for the flotation work at Anaconda.

Part II gives a description of the remodeled concentrator as adapted to flotation. The remodeled concentrator consists of eight sections, each of 2000 tons per day capacity, giving a total of 15,000 tons per day, allowing for shutdowns and repairs.

Part III is a description of the slime flotation plant. It consists of twenty Minerals Separation machines and five Dorr thickeners to dewater the concentrates. The plant is designed to treat approximately 2000 tons of current slime and 1000 tons of pond slime.

Part IV describes the flotation concentrates dewatering plant, which consists of five Dorr thickeners for the

flotation concentrates and another five for the slime. The pulp is delivered to the thickeners by means of baffle boxes, which reach nearly to the rake arms of the thickener. These boxes are surrounded by a second baffle box extending about 18 in. below the surface of the water. These baffles take care of much of the froth. The capacity of the flotation concentrate tanks is 200,000 to 250,000 gal. of pulp per 24 hours. When treating table concentrates these same tanks have a capacity of 1,000,000 gal. of pulp per 24 hours.

The paper was discussed by the following: O. C. RALSTON, E. P. MATHEWSON, DAVID COLE, RUDOLF GAHL, A. L. BLUMFIELD, Mr. CRAMER, F. M. HANDY, A. P. WATT and B. B. GOTTSBERGER. Some of the most important questions asked were: Dr. GAHL: Why is it that in certain places acid may be used on chalcocite as at Anaconda, while in Arizona this practice would be detrimental? This could not be answered. Mr. BLOOMFIELD: What is the effect of alkali? Mr. CRAMER: The use of sodium hydroxide flattens the froth, it cuts down the water used in the launders and makes the product easier to handle. At the Old Dominion it is essential to use sodium hydroxide as it increases the yield. O. C.

TABLE IV—TESTS ON ORE C IN NEUTRAL, ACID AND ALKALINE SOLUTIONS WITH DIFFERENT OILS

Oil No.	Total Time, Minutes	Total Oil, Lb. per Ton	Total Acid, Lb. per Ton	Total Alkali, Lb. per Ton	COPPER*	
					Per Cent	Per Cent Extraction
					Heads: Copper, 1.58 Per Cent	
23	17	0.375	0.00	0	3.83	28.7
	16	0.375	7.36	0	8.61	
	17	0.375	0.00	4	1.53	
11	20	0.92	0.00	0	15.95	29.3
	21	1.48	7.36	0	2.48	
	21	1.29	0.00	6	16.15	
18	20	1.8	0.00	0	16.45	51.2
	20	1.5	7.36	0	2.48	
	20	1.2	0.00	4	22.27	
15	21	1.44	0.00	0	5.84	4.3
	21	1.44	7.36	0	2.77	
	23	1.44	0.00	4	16.17	
16	17	2.1	0.00	0	4.50	33.6
	18	2.7	7.36	0	1.72	
	23	2.4	0.00	8	7.94	
14	20	5.0	0.00	0	2.29	13.5
	18	5.0	7.36	0	1.43	
	19	7.0	0.00	4	12.90	
10	19	8.0	0.00	0	1.24	25.3
	19	10.0	7.36	0	1.43	
	12	8.0	0.00	7	2.29	

*In concentrate samples.

TABLE III—TESTS ON ORE B IN NEUTRAL, ACID AND ALKALINE SOLUTIONS WITH DIFFERENT OILS

Analysis Head: Gold, 0.608 Oz. per Ton, Iron, 5.2 Per Cent

Oil No.	Total Time, Minutes	Total Oil, Lb. per Ton	Total Acid, Lb. per Ton	Total Alkali, Lb. per Ton	GOLD*		IRON*	
					Oz. per Ton	Per Cent Extraction	Per Cent	Per Cent Extraction
23	21	0.375	0.00	0.0	4.50	81.5	8.0	10.2
	21	0.575	3.88	0.0	6.42	76.7	9.0	16.5
	21	0.375	0.00	1.0	4.76	79.7	8.2	9.9
11	22	1.11	0.00	0.0	4.72	82.5	8.5	31.0
	22	1.11	3.88	0.0	6.12	75.8	17.2	41.1
	23	1.11	0.00	4.0	5.64	82.3	13.4	14.8
18	22	1.8	0.00	0.0	10.34	78.2	13.2	17.7
	21	1.5	3.88	0.0	11.52	78.0	14.3	19.6
	22	1.5	0.00	1.0	11.60	81.2	13.1	6.2
15	23	2.88	0.00	0.0	5.06	82.3	5.7	0.0
	21	2.88	3.68	0.0	13.80	74.8	9.6	11.8
	21	2.88	0.00	1.0	5.80	76.0	7.4	6.2
16	21	2.4	0.00	0.0	10.10	81.3	8.6	31.5
	21	2.4	3.68	0.0	12.60	81.2	0.0	0.0
	21	2.4	0.00	1.0	7.88	78.7	11.7	27.3
14	21	12.0	0.00	0.0	5.42	79.1	9.2	32.5
	22	12.0	3.68	0.0	7.22	81.7	12.0	40.3
	19	12.0	0.00	1.0	7.28	78.7	12.1	26.9
12	15	18.0	0.00	0.0	5.88	76.0	7.7	32.3
	20	20.0	3.68	0.0	6.76	81.7	15.0	12.8
	15	24.0	0.00	1.0	9.44	77.0	6.9	14.0
10	23	16.0	0.00	0.0	5.40	88.7	6.1	40.8
	21	16.0	3.68	0.0	4.98	79.5	6.0	41.2
	24	16.0	0.00	1.0	6.10	79.2	6.5	16.7

*In concentrate samples

TABLE V—SCREEN ANALYSES

	Opening	Mesh	Weights	ASSAYS		
				Per Cent	Pb, Per Cent	Zn, Per Cent
		Mm.				
Ore A Through	0.589	28	100.00	0.00	0.00	0.00
	0.417	35	0.43	0.05	0.08	0.08
	0.208	48	12.88	0.07	1.37	1.37
	0.147	100	34.46	0.07	2.24	2.24
	0.104	150	23.76	0.09	6.46	6.46
	0.074	200	10.59	2.19	14.60	14.60
	0.074	200	17.75	19.08		
Ore B Through		200	100.00			
Ore C Through	0.295	48	100.0	2.2	1.58	1.58
	0.208	63	16.7	1.82	1.46	1.46
	0.147	100	16.0	1.82	1.46	1.46
	0.104	150	16.0	1.82	1.46	1.46
	0.074	200	33.3	1.82	1.46	1.46
	0.074	200	11.8	1.73		
	0.074	200				



FIG. 9—INSPIRATION MINING PLANT

RALSTON: An addition of alkali gives a slower settling of the slimes. Alkali acts as a deflocculent on the slimes, liberating the values. Mr. Ralston then asked several very important questions, some of which were answered while others had to go without an explanation, but they started the members thinking along those lines. First, What is the effect of dilution by water on the mineral contained? Dr. GAHL: gives cleaner concentrates, but

the concentrates are harder to obtain and uses more oil. Second, What determines the amount of oil used? Is there a definite ratio of the water to the oil? This remained unanswered. Third, Are colloidal ores harder to treat than granular ores? Both Mr. MATHEWSON and Dr. GAHL claim that colloidal material is more difficult to treat. Fourth, Would it be possible to treat the colloids and obtain a flotation product? Fifth, How



FIG. 10—INSPIRATION CONCENTRATOR

much colloidal material would be permissible? These last two questions remained unanswered. F. S. SCHMERKA mentioned that it would be of great value to determine the density of the pulp when oil is added and when the pulp is diluted. This might lead to some conclusions as to the amount of oil to be added.

Mining and Smelting

The evening session was on **Mining and Smelting**. The chairman was P. G. BECKETT. Most of the papers were on straight mining subjects with the exception of that by W. A. SCHMIDT, which was an illustrated lecture on the Cottrell dust collecting system as used at the International Smelting Company and at a cement works in California. The effect produced by the system was shown experimentally in an interesting manner.

The mining papers read were: "The Block Method of Top Slicing of the Miami Copper Company Mine," by E. G. Deane; "Stoping Methods of Miami Copper Company," by D. B. Scott; "Mine Fire Methods Employed by the United Verde Copper Company," by R. E. Tally; "Ore-Drawing Tests and the Resulting Mining Methods of Inspiration Consolidated Copper Company," by G. R. Lehman, and "Cost and Extraction in the Selection of a Mining Method," by C. E. Arnold.

September 22d at Globe, Ariz.

The last day of the meeting proper was one of greatest interest. The morning was spent at the Mill of the Inspiration Consolidated Copper Company and at the Reduction Works of the International Smelting and Refining Company. It is a well-known and ad-

mitted fact that the mill of the Inspiration is the one most up to date at present. Figs. 9 and 10 are views of the Inspiration mine plant and concentrator. In the mine plant the striking feature is the use of labor-saving devices. Wherever possible mechanical contrivances are employed in place of manual labor. This is the case with the hoist and the ore-distributing system. There is something nearly uncanny about the plant, as one observes the machines working away and practically no human being in the vicinity.

The mill proper needs no further elucidation as the paper by Dr. Gahl gives the full description. The accompanying Fig. 11 gives the complete flow-sheet, which is self-explanatory. The one striking feature of the whole plant is its cleanliness. One seems to feel instinctively that every effort was put forth by everyone to make this plant a landmark in the field of the copper metallurgy.

A good companion to the mill of the Inspiration is the reduction plant of the International Smelting Company, a view of which is

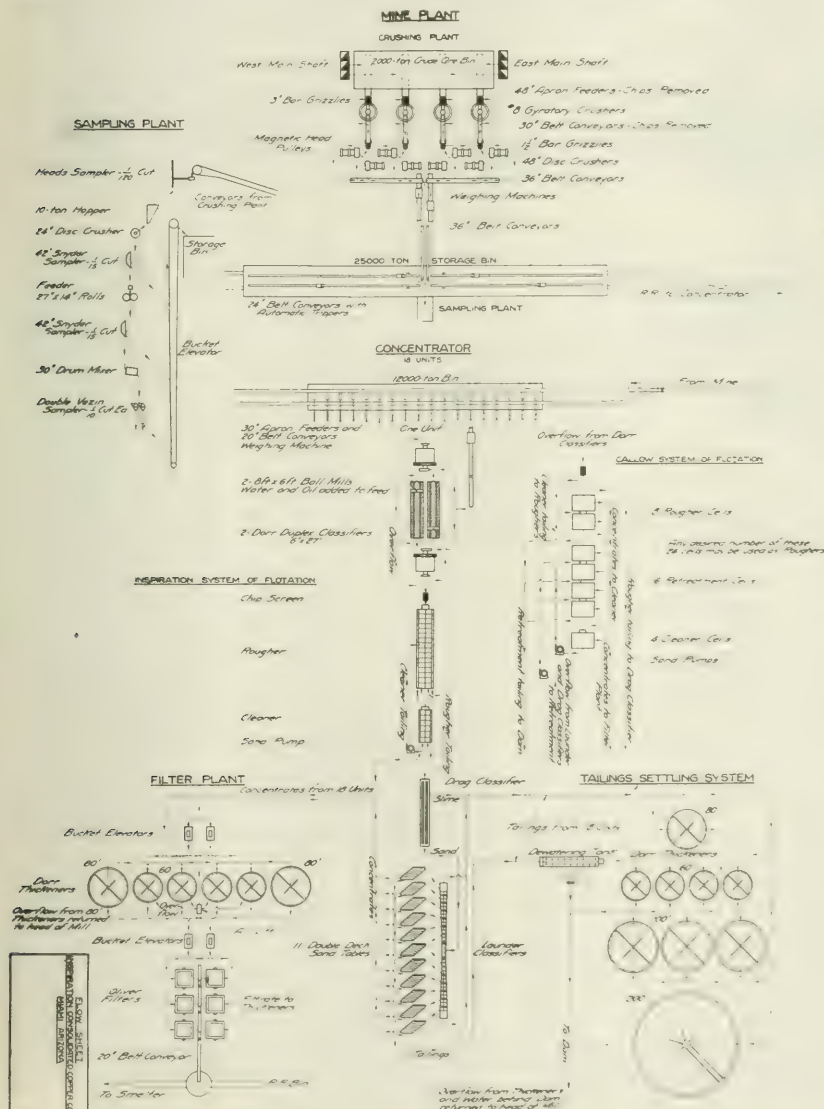


FIG. 11—FLOW-SHEET OF INSPIRATION

FLOW-SHEET of INTERNATIONAL SMELTING COMPANY'S PLANT. MIAMI, ARIZONA.

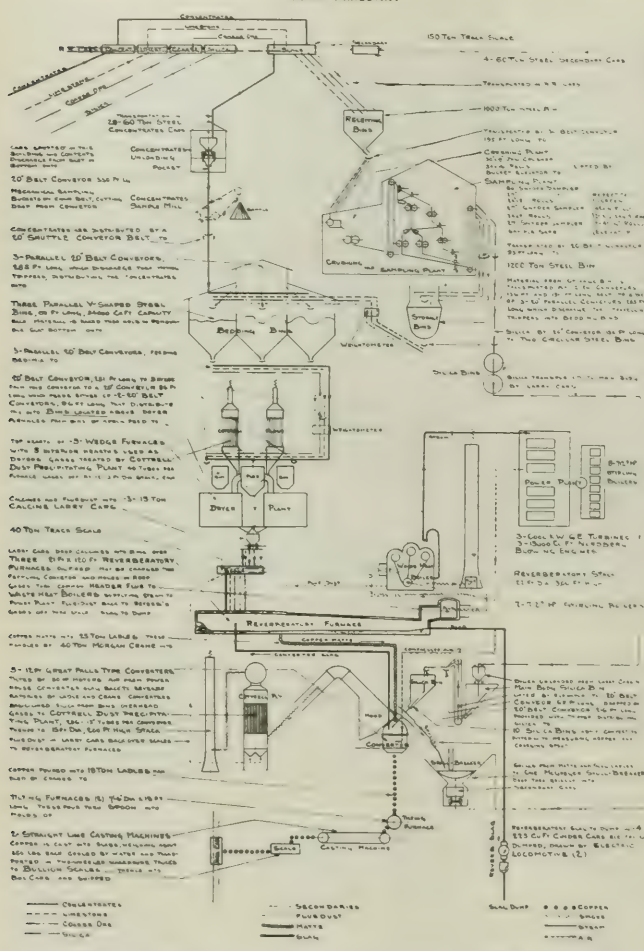


FIG. 12—FLOW-SHEET OF INTERNATIONAL SMELTING COMPANY'S PLANT, MIAMI, ARIZONA

given in Fig. 12. The plant consists of a drying plant, a reverberatory plant and a converter plant. No blast furnaces are used. The Wedge furnaces used are not employed for roasting but merely for drying. The matte produced in the reverberatory furnace goes to the converter department and is blown to blister copper. The plant is very compact and is simplicity itself. Fig. 12 is the flow-sheet of the smelter.

After enjoying a luncheon at the clubhouse of the Miami Copper Company, the Mill of the Miami Copper Company was visited. While the mill of the Inspiration is undoubtedly newer and more up to date, one looks upon the mill of the Miami Copper Company with awe and admiration for a great deal of the development of the flotation process was conducted at this mill and the Inspiration only proves the excellent work which was done at the Miami, for it was no little matter to improve on the Miami mill. Some data may prove of interest. The dry tons milled from January to June, 1916, were 859,485, or 4722 tons per day. The copper in the feed averaged 2.09 per cent, of which 0.32 per

cent was oxidized and 1.77 per cent was present at sulphide. The percentage of copper in the concentrates was 41.74. The total copper in the tailings amounts to 0.56 per cent, of which 0.30 per cent is oxidized and 0.26 per cent is present as sulphide. The recovery of copper is 74.06 per cent.

Fine Grinding

The last technical session was on fine grinding. The session was presided over by B. B. GOTTSBERGER. The first paper offered was by CHARLES LEGRAND on the "Power Plant at Burro Mountain Copper Company." The discussion was conducted by Messrs. GOTTSBERGER, LANGDON and KIDDER.

The second paper was: "Comparative Test of the Marathon, Chilean and Hardinge Mills," by F. G. BLICKENSERFER. The tests were run for several months under actual milling conditions. The Chilean and Marathon mills ran simultaneously for 63 days. The Hardinge mill ran for the first 30 days with an old lining, which was then replaced by a new one. The average results of the Hardinge and the Chilean mills for the 63 days will be compared with the Marathon mill. The tests were made on the Marathon mill. In test No. 1 the feed was the same as for the Hardinge and the Chilean mills. Some time elapsed between Marathon tests No. 1 and No. 2, to determine the best method for handling heavy loads. Three shovel wheels were installed to remove all slimes and the greater amount of water. The tonnage per unit was reduced to 500 tons per day instead of 750. Subtracting the weight of concentrates produced in primary table concentration, and the weight of slimes recovered by the shovel-wheels preceding the Marathon mill, a net weight of 430 tons per 24 hours was obtained. The total recovery of the unit under these conditions was practically the same as the second unit operating three Chilean mills and this paved the way for a heavy tonnage on the Marathon mill.

The results obtained are: that under the conditions of these tests the Marathon mill is far superior to the Hardinge and the Chilean mills in grinding efficiency. Of the Hardinge and the Chilean mills the Chilean is superior to the Hardinge.

On the basis of these results two new mills have been ordered by the Detroit Copper Company at Morenci, Ariz., being 8 ft. long and having a diameter of 4 ft. with the following improvements: The feed scoops have three channels, the entrance to each channel being 108 sq. in., the scoops being placed at the head end of the mill; sectional liners for the head and solid circular ones for the tail end; rigid base, with no tilting arrangement; non-spiral, solid roller bearings; the driving gear is attached to the tail end of the shell, the pulley being supported rigidly by having its bearings set solidly on a separate concrete base.

A lively discussion by Messrs. GOTTSBERGER, KILIANI,



FIG. 13—REDUCTION WORKS OF THE INTERNATIONAL SMELTING COMPANY

FRANKE, MERRILL and THAYER followed this paper. Mr. GOTTSBERGER said that the efficiency of mills is increased by replacing pebbles by steel balls. Concerning the sliming Mr. BLICKENSERFER found that the Hardinge slimed slightly less total feed and slightly more mineral. On the other hand, Mr. KILIANI, in a large number of tests, observed just the reverse. Mr. THAYER: What is the action in the Marathon mill, grinding or crushing alone or both? Mr. BLICKENSERFER: Both. In the Marathon mill there is no spherical contact, but simply linear contact.

A banquet was given in the evening on returning from Miami to Globe in the auditorium of the high school. The toastmaster was S. J. JENNINGS. The evening was enlivened by the following speakers: JOHN E. BACON, "Safety First"; L. D. RICKETTS, "The Growth of the Globe District"; E. P. MATHEWSON, "Why the Young Engineer Should Join the Institute," and finally F. G. COTTRELL, "The Utilization of Waste Products." Further charm was given to the evening by the music rendered by the local orchestra.

This officially terminated one of the most interesting meetings in the history of the Institute. On the 23d automobiles took the party over the Apache Trail, past the Roosevelt Dam, a marvel of engineering, to Phoenix, from where the party left the same evening to enjoy the beauties of the Grand Cañon of the Colorado. Here was the parting of the ways, each one going to his own home and destination, but all carrying with them a feeling of thanks and admiration for Arizona and her people.

Purification of Kaolin.—Some interesting data on experiments with American kaolin were given in a paper presented by CHARLES L. PARSONS at the colloidal symposium of the New York meeting of the American Chemical Society. The large deposits of kaolin in South Carolina and Georgia could not heretofore be used in the pottery industry for white ware, as the titanium and iron oxides in the clay discolored the ware. The Bureau of Mines, in investigating this kaolin, found that a small amount of sodium hydroxide deflocculated the colloids so that the clay readily remained in sus-

pension in water for a long time, allowing the small particles of heavier minerals to be separated out. As a result, co-operative experiments were conducted with the Georgia Kaolin Company, near Macon, Ga., and a plant built for purifying kaolin in accordance with the facts discovered in the laboratory. As a result, many tons of kaolin were purified at an almost nominal cost. The pure china clay so produced was investigated by one of the bureau's experts in two large potteries in the State of Ohio, and it has been definitely shown that these kaolins, at a cost of a few cents a ton, can be converted from a material selling for \$4.50 a ton to a material easily marketable at twice this figure. Furthermore, white tile made from this kaolin, mixed with American feldspar in proper proportions, has been produced of a greater degree of whiteness and a greater breaking strength than the best tile previously produced from English china clay and Cornwall stone. The purified kaolin has also been found to be applicable to white china ware, thus replacing a large part of the English China clay. America should, accordingly, be entirely independent of the importation of foreign material for the white ware industry.

The Jewell Polar Company, manufacturers of Jewell Polar water-distilling and filtering systems, have issued a new, thirty-two page catalog, describing the new improvements in Jewell Polar stills for drinking water.

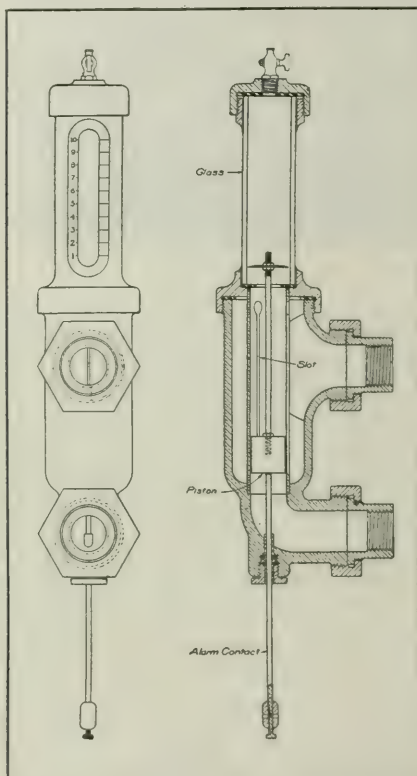
Burgess & Long, chemical engineers of Columbus, Ohio, will open, on November 1, a branch office and laboratory in Chattanooga, Tenn.

New West Virginia Acid Plant.—The Fairmont Chemical Company, Fairmont, W. Va., will erect on Tygart Valley River a sulphuric acid plant with a capacity of 10,000 tons per annum, to be operated by the multiple-tangent system. An auxiliary plant for the manufacture of nitric acid will also be erected. It is estimated the plant will cost from \$75,000 to \$85,000. The building will be constructed of steel and concrete and will be fire-proof. The plans were by Ludwig A. Thiele, Columbus, Ohio, who will be the engineer in charge of construction.

A New Flow Meter for Liquids

A flow meter designed for indicating the flow of liquids in pipes, known as the Vaughan flow meter and sold by the Spray Engineering Company, Boston, Mass., is shown in cross-section in the accompanying illustration. The instrument, which has several interesting features, consists of a cylindrical chamber with suitable pipe connections enclosing a slotted tube through which the liquid must pass.

Enclosed in the slotted tube is a piston which, as the liquid is turned on, is carried up until the exposed area of the slots is sufficient to allow the flow of the liquid up to the capacity of the indicator. An index is at-



GENERAL VIEW AND CROSS-SECTION OF FLOW METER

tached to the upper end of the piston rod, which extends up into a glass tube at the top of the cylindrical chamber. The glass tube is encased in a protecting cover, corresponding to the rise or fall of the piston, to be noted. A scale on the side of the case enables the operator to determine accurately the amount of flow in gallons per minute.

An electric contact consisting of an adjustable brass rod set through an insulated stuffing box at the bottom of the chamber can be connected to a lamp or bell, calling attention when the flow has fallen below a fixed minimum. Contact is established immediately the piston rests on the brass rod. The desired flow of the liquid may thus be secured within the capacity of the instrument. The flow is directly proportional to the area of the slots in the enclosed tube, or to the rise or fall of the piston.

Under test the indicator gives practically a straight line calibration over a large range, and the loss of head in operating the instrument has been found to be negligible, not exceeding 0.004 lb. per square inch with a capacity of 15 gal. per minute. The indicator may be used with screens for dirty water, and can readily be cleaned by unscrewing the top and slipping out the slotted tube and glass.

The Messerschmitt Process for the Production of Hydrogen

By Harry L. Barnitz, Ph. G.

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The Messerschmitt process for the production of hydrogen prior to the European war was not generally known. In a limited way it was known to a few in this country. Since the war many great improvements have been made in this process.

Claims made by Dr. Messerschmitt that his process was superior to all known methods for large productions of hydrogen were accepted in some quarters, but he was not wholly supported at the time he made these statements, due to the fact that only one or two installations were made in Germany and they had not been operated for a period of sufficient length to bear out his claims. More exact information is available now from many plants installed since the war in Germany and other countries. The following article is based on information received from Germany at a very recent date direct from Dr. Anton Messerschmitt.

The military authorities of Germany have adopted the Messerschmitt process for the production of hydrogen to the exclusion of all processes heretofore suggested and in use for installations of large production. Fourteen Messerschmitt plants at a cost of \$20,000,000 are now being operated by the German War Department, having a capacity of 100 cubic meters to 600 cubic meters per hour. Several more plants are in the course of construction; one plant of two units of the Messerschmitt process is in operation in the United States. The hydrogen from this plant is used for hydrogenation of oils.

The production of hydrogen after the system of Dr. Anton Messerschmitt is based on the so-called iron contact method.



FIG. 1—HYDROGEN GAS WORKS AIR SHIP DEPOT, KOENIGSBERG

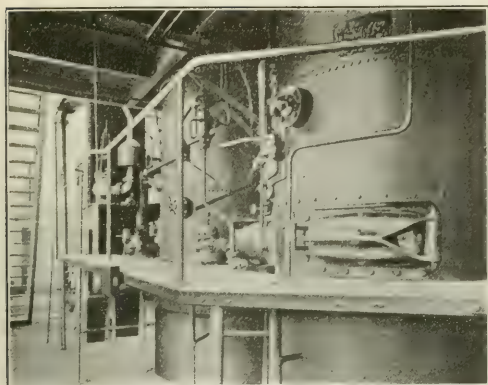


FIG. 2—HYDROGEN GAS GENERATOR, PHOTOGRAPH TAKEN BEFORE THE WAR

This method is based on the fact that if steam is passed over red-hot iron it is decomposed into its elementary constituents, hydrogen and oxygen. The oxygen is taken up by the iron under the formation of iron oxide, while the hydrogen is liberated. The resulting iron oxide can be reconverted into iron by treating it with reducing gases, to which they will give oxygen under formation of carbon dioxide and steam. The process is therefore reversible.

The iron, theoretically speaking, is not consumed. It serves only as a contact mass, as in its glowing condition it is periodically oxidized with steam and again reduced by being treated with special gases. A gas with reducing action is carbon monoxide or hydrogen itself. Therefore, for the reduction such technical gases can be applied which contain these elements in greater quantities, for instance, generator gas, water gas, or coal gas, etc.

Especially adaptable to reduction is coke gas, as it is composed largely of carbon monoxide and hydrogen. These gases can be produced at very low cost, as the actual material necessary is only coal, coke and steam.

Water gas, for instance, is obtained by passing steam of corresponding temperature through a generating box containing superheated coke. The oxygen of the steam combines with the carbon of the coke, form-

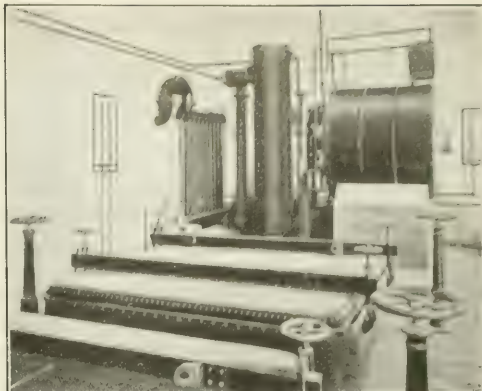
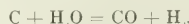


FIG. 4—PURIFIERS, FINAL CONDENSER AND GASMETER

ing carbon monoxide, and the hydrogen is liberated.

The following equation explains the reaction:



The water gas is theoretically a mixture of equal parts of carbon monoxide and hydrogen; practically it contains carbon hydrates and impurities as sulphur combinations, nitrogen and carbon dioxide. For the technical production of water gas, the well known periodically working generators are used. Steam is passed for a while over glowing coke, and the water gas formed is passed through a purifying apparatus into a storage tank. (This is the gas period.)

As the process of forming the gas consumes a great deal of heat, the temperature of the coke is reduced, therefore after about ten minutes the steam supply must be interrupted and air has to be blown through a ventilator into a generator and through stimulated combustion of a part of the coke the required heat is restored. (This is the blow period.)



FIG. 3—WORKING STAGE ABOVE HYDROGEN GAS GENERATOR, PHOTOGRAPH TAKEN BEFORE THE WAR

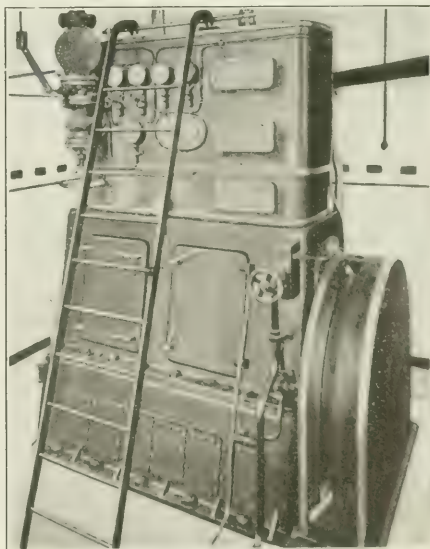


FIG. 5—VERTICAL COMPRESSOR

The products formed by this combustion are removed through a diverting ventilator so that they cannot mix with the gas.

The production of water gas is distinguished by its great simplicity. The generators are extremely reliable to operate, require only limited attention, and can be built for all requirements in units of a generating capacity of 3500 cu. ft. per hour.

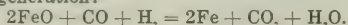
The main advantage of the iron contact method is that the only materials required for the production of hydrogen are coke and water, materials easily and cheaply obtained anywhere.

The chemical change in the production of hydrogen by the iron contact method and the application of water gas as reducing agent are explained by the following formulas.

1. Oxidation period:



2. Regeneration:



These two periods are alternating, and each only of

conditions hard to establish, the contact mass in iron retorts being heated from outside.

Another difficulty encountered in continued generation of hydrogen are the impurities accumulating in the heat and reduction gases. These impurities will form a layer on the surface of the contact mass thereby lowering its progress of reaction by gradual contamination, besides contaminating the produced hydrogen.

In the patented system of Dr. Messerschmitt these difficulties have been overcome. Its fundamental principles are that the hydrogen gas is generated in a generator shaft with separate compartments for heat and contact mass, which are connected in such a way that heating, process of reduction, and generating of gas take place in the interior of one and the same apparatus.

Fig. 6 is a projective reproduction of the three working periods of a hydrogen generator of the Messerschmitt system, explaining the construction of the generator and its working methods.

In a generator shaft, lined with fire brick, two iron

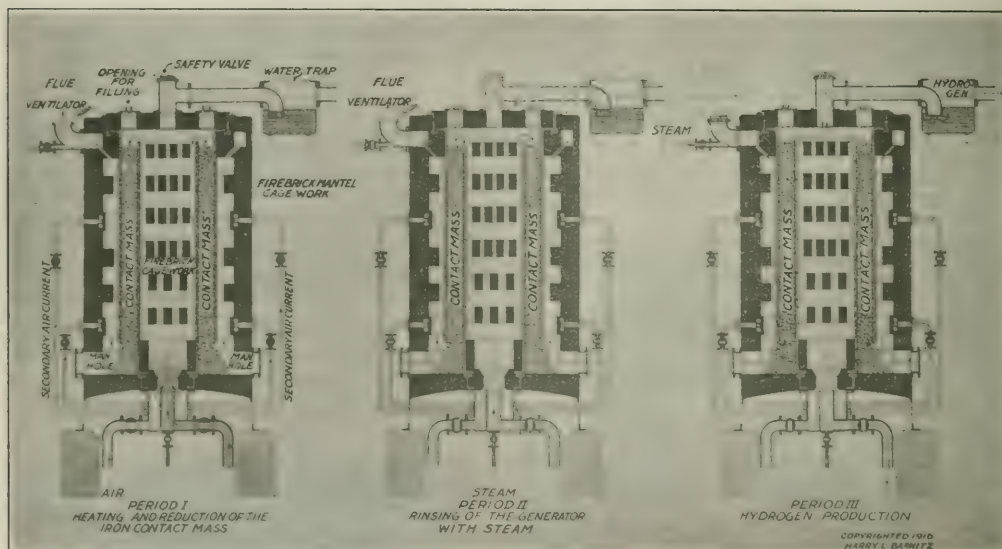


FIG. 6—REPRODUCTION OF THE THREE WORKING PERIODS OF THE LATEST TYPE MESSERSCHMITT HYDROGEN GENERATOR

such duration as to give chemical reaction in a sufficiently short time. The contact mass must at the same time be kept by heating at such a temperature as is most suitable for the process. This temperature is about 700 deg. to 800 deg. C.

The iron contact method as well as the use of iron or iron ore as contact mass, also the use of water gas or similar gases for reduction of same, are well known.

A number of old extinct patents are existing, and a series of suggestions have been made even lately regarding the practical development of this system, some of which have been partly applied in practice. But many difficulties have been encountered in technical production.

It is extremely difficult to obtain an even degree of heat of the contact mass and regulate exactly the high temperature required for the completion of the process quickly without overheating the mass, which under such conditions would cake together or even melt.

The retort ovens which have been constructed for generating hydrogen are difficult to handle, and proper

cylinders are built in, in a vertical position. The inner cylinder rests on the floor of the generator. Between these cylinders the iron contact mass is stored. In the interior of the inner smaller cylinder there is a cage-work of fire brick which serves as storage of heat. The larger cylinder is also surrounded by fire brick cage-work which is incorporated in the construction of the outside fire brick mantle of the generator. For the heating of the cage-work, and for the heating and reduction of the contact mass, reducing gases and air are introduced from underneath into the interior part of the generator, the air in such volume as not to be sufficient for complete combustion of the heating and reducing gases.

The combustibles and the parts of the gas not consumed rise upwards in the inner cage-work, pass through the contact mass downward into the outer cage-work where the rest of the gas is consumed by additional or secondary air current, rising again upwards to pass through the flue into the open. The heat is thereby imparted to the cage-work, at the same time heating and

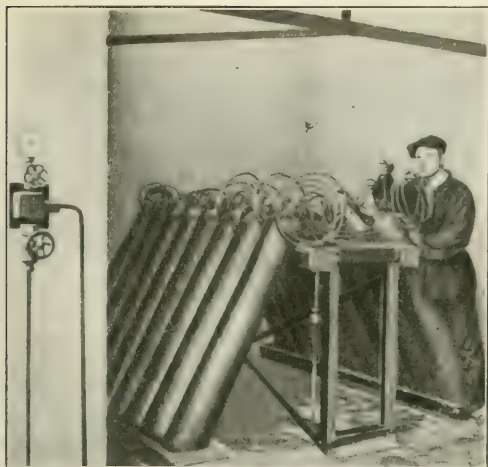


FIG. 7—CYLINDER FILLING

producing the contact mass. The duration of this heating and reduction process is about 20 minutes. After this the supply of heat, reduction gas and air is shut off and steam is introduced from underneath into the generator.

The steam and the carbon dioxide generated from the contact mass are driven out through the flues.

As soon as hydrogen gas escapes with the steam, which can be easily detected by the forming flame, the supply of gas and air is discontinued, and at the same time the ventilator leading to the flue is closed. The so-called rinsing or steaming period now begins which requires only a few seconds; steam being passed through the apparatus as shown in the second diagram.

Then the third period begins. Steam is passed from above into the outer cagework of the generator, and

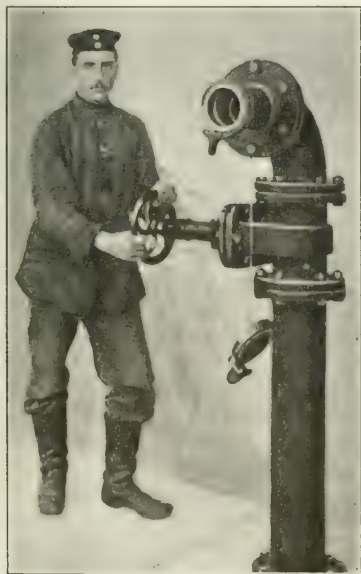


FIG. 8—STAND PIPE FOR FILLING AIR SHIPS

the actual hydrogen production period begins. The steam coming into contact with the glowing contact mass which is now reduced iron is decomposed and hydrogen is liberated with the formation of iron oxide.

The outflow of the generated hydrogen takes place on the top from the middle of the generator into a chamber with a water trap. From there the hydrogen passes through a purifier into the hydrogen gas holder and is then compressed in cylinders or storage tanks. The gas period is of about 15 minutes' duration.

The process is then repeated by again introducing heating and reduction gases and air into the generator. The working method is therefore a periodical one.

The great amount of heat required during the heating and reduction periods is imparted to the contact mass and stored in the fire brick cagework. During the gas period this heat is taken up, the fire brick cagework imparting its heat to the contact mass; besides the introduced steam which passes over the cagework becomes highly superheated and the most effective temperature for reaction is reached. The proper temperature required for this process is between 700 deg. and



FIG. 9—CYLINDER FILLING WITH PROTECTION CHAMBER AT BORSIGWALDE

800 deg. C., as was mentioned before. This temperature is easily reached in this generator.

Overheating, which would impair the life of the contact mass and the other materials is easily avoided. By the construction of the hydrogen generator of this system an even temperature of the contact mass is obtained without danger of overheating, while the required temperature is quickly imparted.

The total consumption of fuel required for the heating and reduction gases and steam used in the production of hydrogen is very low. The actual cost of the hydrogen gas is governed by the cost of coke and other materials and the size of the installed apparatus. The cost, taken from one plant installed in the United States, averages 40 to 45 cents per 1000 cu. ft. This figure includes interest on investment, depreciation, material and labor.

The generator is very readily put into action, and the heating requires only a few hours.

The arrangement of the heating and contact compartments of this generator exclude all possibility of the hydrogen gas being lost or escaping.

The generator gives off very little heat to its surroundings, the fire brick forming an excellent isolator of heat. The workmen are therefore not troubled by heat or gases. One man can easily attend two hydro-

gen generators—his whole duty is to change levers for each working period and read the pyrometer. All lever positions are automatically locked, thus preventing a wrong position of ventilators.

To replace the contact mass after long use, openings for filling are arranged on the top of the generator, and to remove it, Morton doors are placed on the lower part of the generator mantel.

The heat and reduction gases, as well as the steam, if not available, are produced by the use of a coke generator and steam boiler respectively. One coke generator and one steam boiler are sufficient for several hydrogen generators. The additional requirements for a complete hydrogen gas plant are a few unskilled laborers who can acquire the necessary training in a short time.

The hydrogen produced by this method is nearly chemically pure (99.2 per cent); only traces of nitrogen are present. The purification of the hydrogen gas leaving the generator is done in a simple scrubber in which the dust particles are removed by water. To remove traces of sulphur combinations and carbon dioxide, the gas is passed through a purifier containing iron ore and lime.

Calorizing as Applied to Power Plant Equipment

One of the interesting new things which the research laboratory of the General Electrical Company at Schenectady has developed in the past few years is a process for impregnating iron and steel, with an aluminium alloy known as calorizing. The resulting material is a rich ferro-aluminium of great hardness and possessing heat-resisting qualities much in excess of iron and steel. Calorizing was described in this journal, Vol. XII, p. 730 (Nov., 1914), and Vol. XIII, p. 325 (May, 1915).

One of the interesting new applications of this process is to soot blowers and other power plant equipment. A year ago the Diamond Power Specialty Company, Detroit, Mich., secured sole right as lessee from the General Electric Company to the use of this process in the manufacture of soot blowers and other power plant equipment. The calorized metal is sold in these soot blowers, etc., under the trade name of "insuluminum."

Soon after the calorization process was announced the Diamond Power Specialty Company's engineers instituted an extensive investigation, lasting many months, of the new material. In addition to the mechanical and thermal tests described later, trial installations of soot

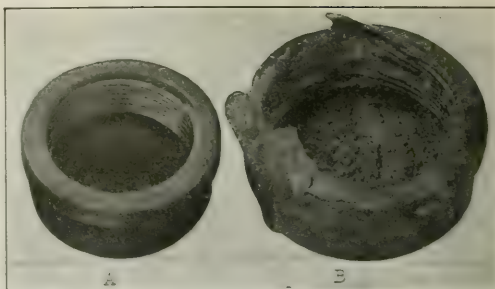


FIG. 1—INSULUMINUM AND EXTRA HEAVY STEEL CAPS AFTER EXPOSURE TO THE COMBUSTION GASES IN THE FURNACE OF A STIRLING BOILER AT A TEMPERATURE OF OVER 2500 DEG. FAHR. A IS "INSULUMINUM. B IS "EXTRA HEAVY"

blower units were made in all the different types of water-tube boilers. Units were placed at points in the passes where the temperature ranged from 1800 to 2000 deg. Fahr. The need of blowers at these locations had long been recognized, but their application had been con-

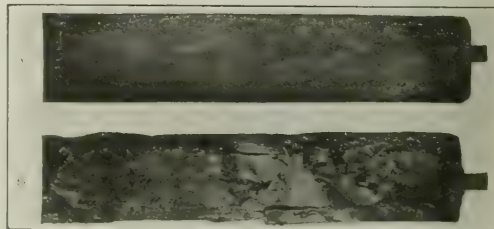


FIG. 2—APPEARANCE OF INSULUMINUM AND PLAIN PIPE AFTER THE SULPHUR DIOXIDE TEST. "A" IS INSULUMINUM. "B" IS PLAIN PIPE

sidered impracticable. In the tests there was no sign of scaling or disintegration from the long exposures to combustion gases at the high temperatures obtaining, and successful installations during the past year have fulfilled all the maker's expectations.

One of the first questions arising in connection with the adoption of calorizing to soot blowers was its

ability to withstand the stresses of hard service. The mechanical properties of the new material had to be determined accurately. On this point the General Electric Company stated:

"The coating produced by calorizing is so hard that considerable effort is required to break through it with a file. Consequently, such scratches or scrapings as it receives in normal handling need not be feared at all."

To supplement this information, the Diamond Power Specialty Company conducted a long series of severe tests of insuluminum tubes, subjecting the metal to bending, flattening and hammering processes. The results proved conclusively the homogeneity of the mass, and its ability to withstand severe treatment without failure.

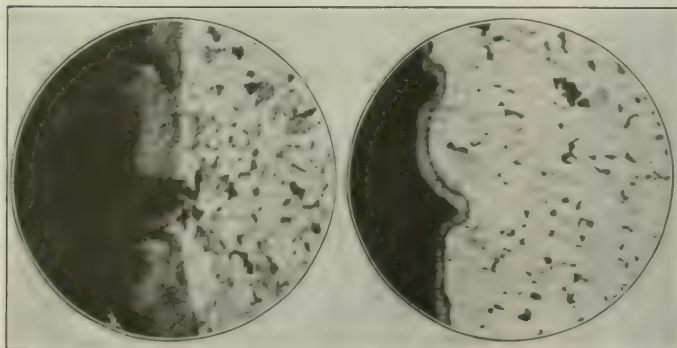


FIG. 3—OUTSIDE BEND AND FIG. 4 INSIDE BEND OF FLATTENING TESTS SHOWING HOMOGENEITY OF MASS AND STRUCTURE AFTER CALORIZING (LIGHT PORTION) MAGNIFIED TO 80 DIAMETERS. MICROPHOTOGRAPHS BY NATIONAL TUBE CO.

The calorized metal will resist for an indefinite time the continued action of temperatures up to 1000 deg. C. (1800 Fahr.). The oxidation of iron and steel becomes pronounced at 500 deg. C., and increases rapidly from this point on.

In Fig. 1 two caps of the type used on soot blowers are shown. These were placed for a short period in a furnace with a temperature of 2500 deg. Fahr., and then plunged into cold water.

The results of a sulphur dioxide test are shown in Fig. 2. Two pieces of pipe, one calorized, the other extra heavy wrought iron, were run side by side in a furnace at 1500 Fahr. in an atmosphere of sulphur dioxide for four hours. At the end of this time the ordinary pipe was so badly decomposed that the experiment was discontinued. The calorized pipe was in as good condition as before the test. In Figs. 3 and 4 are shown microphotographs of the structure of a calorized section after flattening tests.

The calorized metal oxidizes around 1100 deg. C. If the alumina film is broken, scaling will set in at a temperature above 1050 deg. C., but if the film is unbroken the scaling temperature will be higher.

The high heat-resisting quality of the calorized metal makes it much less subject to warping than cast iron or steel.

New Industrial Development Near Pittsburgh

The last stretch of unoccupied river frontage on the Ohio River between Pittsburgh and Wheeling, is about to be opened up, according to an announcement of Ralph W. Cooke, industrial agent, Pennsylvania Lines West of Pittsburgh.

A new line twelve miles in length is to be constructed by the Pittsburgh, Cincinnati, Chicago and St. Louis Railway Company (Pan Handle), commencing at Chester, W. Va., and skirting the south bank of the Ohio River east as far as the mouth of Raccoon Creek, which is about three miles below Beaver.

The Pan Handle now has a branch known as its New Cumberland Branch, from New Cumberland Junction, just east of Steubenville on the main line, north through the thriving industrial towns of Weirton, New Cumberland and Chester, a distance of approximately twenty-three miles and the new line will be a continuation of this branch. The move has been contemplated for some time, as is indicated by the fact that the road has owned the necessary right-of-way for several years.

Construction will be started immediately and it is the intention to have the extension in complete operation some time in the coming year. Ferguson & Edmundson of Pittsburgh have been awarded the contract for the construction of the first portion of the road.

The importance of this development lies in the fact that it will open up extensive acreages of high, level ground, with river frontage suitable for large manufacturing plants. Large tracts of this character, level and at the same time high enough to be free from the possibility of overflow in times of flood, have become exceedingly scarce along the Upper Ohio Valley, a territory remarkable for the industrial development that has taken place in recent years, particularly in the iron and steel industry.

The Steel Corporation has plants at Mingo Junction, Steubenville, Wellsville, Martins Ferry and Bellaire in Ohio and at Chester and Wheeling in West Virginia, all of them along this stretch of river front.

The LaBelle Iron Works has large plants at Steubenville and Wheeling and is now constructing at Follansbee, across the river from their Steubenville plant, a battery of by-product coke ovens.

The Pittsburgh Crucible Steel Company's furnaces and mills at Midland are one of the largest developments in this valley in recent years.

The Phillips Sheet & Tin Plate Company plants at Steubenville, Ohio, and Weirton, W. Va., and the Follansbee Bros. works at Follansbee, W. Va., are continually being enlarged to meet the increasing demand for their products.

The Whitaker-Glessner Company, with plants at Wheeling and Martins Ferry, Ohio, have recently purchased a large acreage at Beech Bottom for open-hearth furnaces, sheet bar mills and ultimately blast furnaces. The Wheeling Steel & Iron Company have made extensive additions to their tin plate department at Yorkville.

In addition to this development of the iron and steel industry should be noted the establishment, about two years ago, of the plant of the Prime Western Spelter Company at Yorkville producing sulphuric acid, and the immense electric generating plant of the American Gas & Electric Company at Beech Bottom, W. Va., with a capacity of 250,000 hp.

There can be no question that the Upper Ohio Valley is susceptible of even more wonderful development in the future.

At Georgetown, at Shippingport and at the mouth of Raccoon Creek are hundreds of acres of ground which are believed to be admirably located and ideal for the construction of large steel mills, chemical plants and other industries requiring large tracts of land and an abundant and never-failing supply of good water.

The whole country back from the river is underlaid with a 6 or 7-ft. vein of Upper Freeport coal, which is not only excellent for steaming purposes, but with the modern by-product ovens will produce a very good grade of coke with the usual by-products, and within a short rail haul are what are known as the Pan Handle District Mines (Pittsburgh seam coal), providing one of the best steaming and gas coals in the world.

There is also considerable clay available which will probably mean the establishment of brick and sewer pipe plants similar to those now existing on both sides of the Ohio River south from East Liverpool and Chester to Steubenville.

The big electric companies will play an important part in the future development of the valley and are making arrangements to extend their lines as fast as the demand for power warrants. In addition to the new plant of the American Gas & Electric Company mentioned above, the Duquesne Light Company and the West Penn Power Company are enlarging their power plant facilities and adding miles of new high tension lines. It is stated that electric current can be produced and sold in the Upper Ohio Valley "as cheaply as at any other location in the country."

Personal

Mr. H. Reeve Angel, of Messrs. H. Reeve Angel & Co., London, England, representing Messrs. W. & R. Balston, manufacturers of the well-known Whatman filter paper, was an interested visitor at the National Exposition of Chemical Industries.

Mr. George A. Burrell, formerly in charge of research work in gas and related investigations for the Bureau of Mines, Pittsburgh, Pa., has resigned his position to enter consulting work. Mr. Burrell has been with the Bureau of Mines for twelve years and is well known for his work and publications on mine gases, natural gases, gasoline, acetylene and illuminating gas.

Mr. E. J. Cornish, formerly vice-president, has succeeded the late W. W. Lawrence as president of the National Lead Company.

Mr. H. R. Hanley, formerly general manager of the

Bully Hill Company, has been appointed superintendent of the Mammoth Company's new \$350,000 electrolytic zinc plant that is to be erected near the Mammoth smelter in California.

Mr. O. C. Ralston, assistant metallurgist of the U. S. Bureau of Mines, with headquarters at Salt Lake City, is now making an extended trip through the Southwest for the purpose of gathering information in regard to the low-grade and complex lead and zinc ores of that part of the country.

Mr. J. W. H. Randall has resigned his position with the Curtis Bay Chemical Company, and has become associated with the West Virginia Pulp & Paper Co., at its Piedmont plant.

Dr. Walter F. Rittman was recently in Texas in the interests of his oil-cracking process.

Mr. I. Schoenawa, formerly of Siemens & Halske and joint author of a book on electric steel furnaces, has been appointed managing director of the Charleston Steel Company, Charleston, W. Va.

Several changes and appointments in the chemistry department of the University of Illinois have recently been made. Professor Richard C. Tolman, recently at the University of California, has been appointed professor of physical chemistry to succeed Professor E. W. Washburn, who has been appointed head of the department of ceramics. Dr. Roger C. Adams has been appointed assistant professor of organic chemistry to succeed Dr. C. G. Derick, who is organizing a research laboratory for the Schoellkopf Aniline and Chemical Works in Buffalo. Dr. Horace G. Deming, recently returned from the Philippines, has been appointed associate in chemistry to assist in the instruction in general chemistry and qualitative analysis. Professor C. W. Balke, formerly at the head of the division of general chemistry and qualitative analysis, is organizing a research laboratory for the Pfanstiel Company in North Chicago which is engaged in the application of rare metals to industrial uses.

Industrial Notes

Counter-Current Decantation for Chemical Industries.—The Dorr Company, Denver, Col., has issued a new catalog, No. 8, dealing with continuous counter-current decantation for chemical industries. The use of the Dorr apparatus is well known to metallurgists, but it was with the idea of acquainting chemical engineers and those connected with chemical industries with the possibilities of this apparatus that the catalog was prepared. On account of the confidential nature of all work in connection with the chemical industries, it was impossible to publish many data concerning the operation of Dorr equipment in such plants. A number of flow sheets are, however, given with the company names omitted. Among the interesting applications are the manufacture of caustic soda from soda ash and lime, alum from bauxite and sulphuric acid, borax from colemanite, barium carbonate from barium sulphide and soda ash, extraction of iron stains from barytes, and phosphoric acid from rock phosphate.

The Tivani Steel Company, Belleville, Ont., Canada, which has been experimenting for some time on an electric smelting process for the direct reduction of refractory ores, is now about to engage on a commercial scale in the manufacture of high-speed molybdenum steel. A three-phase electric furnace is used.

Electrolytic Zinc.—Preliminary work on the new electrolytic zinc plant of the Mammoth Copper Co., was started a short time ago at Kenneth, Cal. The plant will be erected on Big Blackbone Creek, above the Mammoth smelter and will cost about \$350,000.

Corrosion.—The Pacific Foundry Company, San Francisco, has issued a catalog describing its product, corrosion, an acid-resisting machineable iron. It is a high-silicon alloy made by a specially developed process for resistance to corrosion of acid and alkali solutions.

Flotation Oils.—The General Naval Stores Co., New York City, has prepared a booklet describing the flotation oils which it supplies. The primary object in writing this booklet was to get together specific information on flotation oils of a kind which would be most useful to the man in the mill, rather than addressing it to metallurgists who have had special training in this field. An outline is made of the "frothing" and "foaming" properties of various kinds of oils, with suggestions for combining them to produce the proper combination of physical properties to successfully treat a given ore. This booklet sums up the company's observations on oils as applied to flotation, both through letters from operating companies and investigators, whose comments have been invited, and from observations in actual large scale tests conducted at mills in the West.

Fellowship for Asphaltic Research.—With the co-operation of Harvard University and the Massachusetts Institute of Technology, the Barber Asphalt Paving Company has established at these institutions a fellowship for research in asphaltic materials and their uses. The fellowship is to be known as "The Clifford Richardson Fellowship." Mr. Richardson is a distinguished alumnus of Harvard and this, taken in connection with his great contributions to asphaltic highway construction and his work in the chemistry of bitumens, makes the designation of the fellowship particularly appropriate. The appointment of the incumbent of the fellowship and the choice of subjects for investigation, as well as the disposition to be made of the results of such investigations as may be undertaken, are to be decided by the Institute faculty or the joint committees of the University and the Institute having control of engineering work.

New Officers of Institute of Metals.—The officers elected for the coming year at the annual meeting of the American Institute of Metals in Cleveland are as follows: President, Jessie L. Jones, Westinghouse Electric & Mfg. Company, Pittsburgh, Pa.; secretary, W. M. Corse, Titanium Alloy Mfg. Company, Buffalo, N. Y.; senior vice-president, George C. Stone, New Jersey Zinc Company, New York; vice-presidents, R. S. B. Wallace, National Cash Register Company, Dayton, Ohio; William B. Price, Scovill Manufacturing Company, Waterbury, Conn.; George K. Burgess, Bureau of Standards, Washington, D. C.; deCourcey Browne, Goldschmidt Thermit Company, New York City; Harold J. Roast, the James Robertson Co., Ltd., Montreal, Que.; J. P. Salter, Ohio Brass Company, Mansfield, Ohio; F. H. Schutz, H. Mueller Manufacturing Company, Decatur, Ill.; W. A. Cowan, National Lead Company, New York; H. S. Gulick, More-Jones Brass & Metal Company, St. Louis, Mo.

Leather Investigations.—The Council of the American Leather Chemists Association has outlined the following work which will be subjects for committee investigation during the winter 1916-17: Analysis of Tannery Effluent; Dye Testing of Leather with Artificial and Natural Dye Stuffs; Solubility of Hide Substance in Sodium Chloride Solutions; Effect of Alkali on the Soaking of Dry Hides; Determination of the Ash Tanning Materials and Leather; Disinfection of Hides; Analysis of Sulfonated Oils; Comparative Analysis of Tanning Materials by the A. L. C. A.; Official Methods; Effect of Hard Waters on Tannin; Determination of Free Sulfuric Acid in Leather.

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Financial and Construction News

In this issue we publish for the first time an industrial news department on pages 546 to 548. The information has been arranged under two headings. Under the first heading "Financial" information is given on newly incorporated chemical and metallurgical companies, changes in capitalization, etc. These items are arranged alphabetically by companies. Under the second heading "Construction and Operation" announcements are included of proposed new plants, additions to present plants, and changes requiring new equipment. These items are arranged alphabetically by states, and by cities in each state. Very little information concerning a company's plans for location of plant can be obtained from the mere incorporation announcement. Consequently this information is arranged alphabetically by companies. Construction news are classified alphabetically by states, as this arrangement not only shows where developments in the chemical and metallurgical field are taking place, but makes it convenient for reference.

Fashion and Style in Chemistry

It is not necessary that a man have a wife and daughters to feel the rod of style or to come under its sway. We have known men whose trousers bagged at the knees, who scorned the nail-brush, who shaved once or twice a week; men of bedribbled waistcoats and lop-tailed coats, who were the slaves of fashion more abject than the fluffiest debutante. Fashions are like faith and include all sorts and conditions of men, while the quality of dress known as "Schneidigkeit" in German and qualified by "chic" in French, is but a minor manifestation. Fashions and styles are of the mind even as they are of the body and its raiment. Hips may be broad in the spring and narrow in the fall or vice versa, and this may become a ruling thought among many women; it may change the design of corsets or bull the market in padding; and yet it is not so far-reaching as a change in the styles of thinking. These are very contagious, and their rule is more severe. Time was when Byron was a great poet, before he suffered his eclipse, and Herbert Spencer, a leader of thought in his day, is now scorned or forgotten. Fifteen years ago the man on the street was wont to buttonhole his acquaintances and urge them to read Benjamin Kidd's Social Evolution, to improve their minds. Kidd died the other day, almost unknown among the world of readers.

Within the past decade or two, a new fashion of teaching chemistry has arisen and we think it timely to consider its effect. Those of us who are old enough to feel the twinges of rheumatism now and then and have

an acquaintance with gout that has lost its humor, recall the grand wedding of chemistry with physics and we were all there, some in mufti and some in wedding garments. It was a grand style-setting affair. At the christening of Physical Chemistry, some of us were not bidden and others have dropped out of the circle of fashion, but they are back-numbers and out of the game. Physical chemistry is the dashing young hero of the day and we must not only recognize him but do homage unto him if we would have recognition among our fellows. This is right, because physical chemistry has a great deal to say. It is a subject of such vast importance that we dare not neglect it. Its philosophy is all-embracing and has to do with the reasons why things happen. The point that we desire to make, however, is that it is also worth while to study what really does happen as well as the reasons why. Here is where the prevailing fashion of crowding into study as much physical chemistry as students can stand, no matter what the subject may be and as often as there is a chance, may cause the chemical aspirant to miss a thing or two. Reactions still take place, whether they are explained or not, and it is worth while for the chemist to know what they are. They are facts, often baffling facts, and yet they are persistent. It seems to us that they should be learned, learned by heart, so that the young chemist may know them. The reasons why are of vast importance and the search for them whets our curiosity, without which we are of no avail in research. But chemistry has to do on the whole with the ways of stuff and these must be known no matter why they happen. Explanations come after a fact as well as before it, and this is why we believe in drilling in the reactions rather more thoroughly than is the tendency today. We should be the last on earth to decry the value and use of physical chemistry; we are merely raising our voice against the neglect of reactions.

Let us consider a few examples in fancy to make our contention clear. Suppose the elements were families or corporations and had to look out for their reputations. The passion for self-justification among families, corporations, and, indeed, among all of us, is such that we always contend that we are misunderstood when we lose standing among our fellows. Now if tin were a corporation as we have suggested, then it would need the Hon. Elihu Root of New York and Mr. John G. Johnson of Philadelphia to plead for the integrity of its purpose, while to keep it out of limbo on charges of totally unwarranted perversion of the laws of more bid-dable elements, it would need Messrs. Samuel Untermyer, John B. Stanchfield and Abe Levy. With this imposing array of counsel, we should be persuaded of everything they wanted us to believe about tin, but would we really understand it? Would we have the truth, which is all the facts about it in their right relation, in our minds? What would we know about tin when these learned gentlemen had finished with us? Counsellor Levy would have thrown out all evidence of its irregular ways on the ground that the testimony was incompetent, irrelevant and immaterial. Counsellor Stanchfield would have carried us away with his elo-

quence over its silvery beauty. At about this point we should learn that our rich uncle who is growing old and a little uncertain as to how he will leave his money is firm in the opinion that those whipper-snappers that question the regularity of the behavior of tin are a lot of ignorant blatherskites. Mr. Untermyer would persuade us that the whole rumpus about it was a stock-jobbing trick that originated in Wall Street and he would give us the number of the Street and the name of the firm responsible for the iniquitous calumny. Messrs. Root and Johnson would demonstrate the elemental nature of tin and leave us self-respecting and convinced that it is innocent of all allotropy and that its behavior is, in effect, the standard of all metals; that in whatever measure metals differ from tin in their reactions, in so far are they, not tin, irregular.

It would be a delightful entertainment, but it would not fit us for work with tin. The analogy that we are trying to indicate is that while physical chemists do earnestly seek the truth, they haven't gathered in all the facts yet and we need a lot of facts which they have not collected.

Nothing is so sorely needed in general culture to-day as chemical philosophy. It teaches the larger laws than those writ upon the statute books, the need of correlation, and the inevitability of consequences. But young chemical engineers should know reactions better, know them as the multiplication table; have them in the backs of their heads and be in a position to draw upon memory for them. It does the historian of Early America no harm to know that Columbus landed in 1492. He does not deduct the date from his knowledge of contemporary tendencies and spirit of adventure; he boned for it and learned it. And that is the only convenient way to learn of a great many reactions.

"It Can Be Done"

In many offices there has lately been hung a motto "It can be done!" The times are so strenuous that men hardly have time to notice the motto, but the suggestion embodied is being carried out. Under pressure of the unprecedented conditions existing men are doing things that before the war would have been regarded as impossible. This is the case both with steel producers and with steel consumers. Steel producers have found that ferromanganese is not the *sine qua non* it was once considered. Special grades of steel are made at mills whose mission was supposed to be the manufacture of ordinary soft steel exclusively. Departments are being operated with fewer men than was supposed to be necessary.

Steel consumers who felt that they must have a certain description of steel have had the choice of some other description of steel—or nothing, and they have not selected the nothing. The votaries of open-hearth steel have accepted Bessemer. Those who had to have soft steel have chosen carbon steel, the now so familiar "shell billet discards" rather than nothing and have found they were able to get along with it. Machine shops have trained common labor to do lathe work on shell parts with an accuracy they doubted could be compassed with their most experienced machinists.

Volumes could undoubtedly be written of the new things men have done in the steel trade and its allied industries, if the men who have done them had the time to write, but that is precisely what they do not have.

If in the United States unusual things have been done, still more remarkable must be the things that have been accomplished abroad in the countries at war. The English and French came to us with demand that we roll steel rounds for shells, and were disappointed at the deliveries received. When Italy entered the war the United States was combed over for old steel locomotive and car axles, to be converted to the same use, with the result that the last sales have been at almost double the regular consumer would care to pay. And some marvelous things which Germany has done—notably in connection with nitric acid—have been recorded from time to time in these pages.

Export and Domestic Steel Demand

Early in the present period of steel trade activity there was a belief in many quarters that the activity was produced chiefly by an export demand. That notion no longer obtains, as the facts are now well apprehended. Still, it is desirable to lay down the measuring rod occasionally upon the latest statistics available in order to observe the precise relation between domestic and export demand. In the magnitude of the domestic demand thus disclosed there are certain indications as to what is to be expected when the war ends.

The government's export statistics classify under the heading "iron and steel" all commodities that are really such, including scrap, pig iron, unfinished steel, rolled steel, wire products, pipe, machinery, hardware, cutlery, etc. Outside this classification are various manufactures in the production of which iron and steel enter, such as electrical machinery, agricultural machinery, automobiles and railway rolling stock except locomotives, as locomotives are placed under iron and steel. The proportion of iron and steel exports to total exports has been as follows:

	Per cent
1912	12.0
1913	11.8
1914	9.5
1915	10.9
August, 1916	16.9

The value of iron and steel exports is large, \$86,296,703 last August, but the exports of all merchandise are extremely large, \$509,894,479 in August, almost two and one-half times the average monthly exports in the record calendar year before the war. The increase in the proportion of iron and steel from 1912 to 1913 to August of this year is only 42 per cent. There are many commodities the proportion of which has increased much more.

Doubtless the values per unit of quantity have increased much more in iron and steel than in merchandise generally, as in the domestic market the common steel products have more than doubled in value since the low level of December, 1914, while the present values

are nearly double the average market values of 1912 and 1913. Another method of comparison is to ascertain the relation between the production of pig iron and the weight of the iron and steel products exported that are returned by weight. In 1912, the year of largest iron and steel exports before the war the weight of iron and steel exports was 2,948,466 gross tons, which represented 10 per cent of the 29,726,937 tons of pig iron produced in that year. In the first eight months of this year the exports amounted to about 3,710,000 tons, while the concurrent pig iron production was about 26,100,000 tons, showing a proportion of 14.2 per cent. It is interesting to observe that this comparison, on a totally different basis, shows precisely the same increase in the proportion, 42 per cent, as is shown by comparing the value of iron and steel exports with the value of all exports.

The exports of merchandise in the manufacture of which iron and steel is consumed but which is returned under categories other than iron and steel, have increased quite sharply, but the total value is not large as compared with iron and steel, nor is the quantity large as compared with the domestic production. Thus in the first eight months of this year 56,599 automobiles were exported, valued at \$64,640,068, but the number exported was only about 6 per cent of the number produced. A comparison of values would probably show a slightly higher proportion.

The comparison by using the total weight of iron and steel exports may be objected to on the ground that the total includes such widely different commodities as pig iron and billets on the one hand and wire nails and boiler tubes on the other, but the more one studies the statistics the more fully he realizes that after all iron is iron despite the facts that the open-hearth furnace receives pig iron and scrap and the steel rolling mill delivers a much smaller tonnage of rolled steel than it receives of ingots. It is illuminating therefore to make a comparison by deducting the weight of iron and steel exports from the pig iron production. For the year 1913, the year of largest domestic demand before the war, the remainder is 28,235,000 gross tons. For the first eight months of this year the remainder is 22,400,000 tons, or at the rate of 33,600,000 tons, suggesting an increase in domestic demand of 19 per cent in three years. The actual increase is less, but not much less. The showing is distorted somewhat by there being more iron and steel than formerly involved in exports which do not enter the tonnage category.

This large domestic demand is occasioned by the general industrial activity, and some of that activity is directly produced by the war demand for commodities other than iron and steel, but a great deal of the activity is caused by the country having been made rich. The wealth will remain after the war, at least in large part. At the present time a great deal of it is undistributed. Funds are being held because it is physically impossible to invest them or because their holders desire to await the more settled times that will follow the war. Eventual investment will necessarily occur and that will occasion a new demand for steel.

Readers' Views and Comments

The Electrolysis of Cryolite-Magnesium Oxide Mixture

To the Editor of Metallurgical & Chemical Engineering

SIR:—From analogy with the fact that aluminium is made by the electrolysis of aluminium oxide dissolved in melted cryolite, it might appear probable that if magnesium oxide were substituted for aluminium oxide, magnesium would be deposited at the cathode in place of aluminium. This conclusion, however, is not theoretically correct. In the mixture of magnesium oxide and cryolite the following ions exist, (possibly also more complex ions): Na^+ , Mg^{++} , Al^{+++} , F^- , and O^{--} . On electrolysis, those ions would be liberated whose decomposition voltage is the least. In this case, these are the aluminium and oxygen ions.¹ Therefore the products of the electrolysis of cryolite-magnesium oxide mixture should be the same as those of the electrolysis of cryolite—aluminium oxide mixture. As the electrolysis proceeds, with the removal of aluminium and oxygen, aluminium oxide would have to be added to keep the composition of the bath constant.

This is similar to the case of aqueous solutions of ions whose decomposition voltages are higher than those of hydrogen and oxygen ions, for example, sodium fluoride. When a solution of sodium fluoride is electrolyzed, hydrogen is liberated at the cathode and oxygen at the anode, and the only function of the sodium and fluorine ions is to carry the current through the solution. The most easily deposited ions then carry it from the solution to the electrodes.

The following experiment proves the correctness of the above conclusion.

A graphite crucible of 4 in. inside diameter was used as the cathode of an electrolytic cell. The anode was a 2-in. graphite rod. A mixture of ten parts of cryolite to one of magnesium oxide was melted and electrolyzed with from 6 to 8 volts and from 150 to 200 amp. The anode effect², frequently interfered with the electrolysis. After the cell cooled off it was broken open and pieces of metal were found which were easily recognized as consisting principally of aluminium. There were other smaller pieces of metal which had the appearance of silicon and which were probably silicon aluminium alloy. Counting all metal obtained to aluminium the current efficiency was about 20 per cent. There was no odor of fluorine, and the mixture of cryolite and magnesium oxide has three to four times the conductivity of cryolite alone.

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Dielectric Constants and Flotation Values of Oils

To the Editor of Metallurgical & Chemical Engineering

SIR:—The following results of some experiments undertaken to see what relation, if any, existed between the dielectric constant and the flotation values of various oils, may prove interesting.

The dielectric constants were determined by Dr. Herman Schlundt of the University of Missouri and the flotation values by Charles Y. Clayton and C. E. Peterson of the Missouri School of Mines at Rolla, Missouri.

¹It is here assumed that none of the ions are so dilute as to change their relative positions in the electrochemical series.
²Electrochem. and Met. Ind., 7, 15 (1908).

Oil	Behavior in Flotation	Flt. Value	Prelim. Dielectric Constant Approx.
Citronella	Frothing, giving an ephemeral small bubble froth.	30.0-74	4.38-4.83
Orange peel	Thick pulpy froth.	21.0-76	2.0-2.33
Pine oil	Frothing, giving an ephemeral small bubble froth.	16.0-60	4.42
Lemon oil	Frothing, giving an ephemeral thin froth.	25.0-68	2.95
Cresylic acid	Frothing, giving a more lasting large bubble froth.	32.0-71	9.80
G. N. S. No. 8	Frothing, giving large stiff bubbles.	32.0-61	4.36
G. N. S. No. 17	Frothing, giving large thin bubbles.	32.0-75	12.0
G. N. S. No. 18	As above.	35.0-71	9.8
G. N. S. No. 22	Frothing, giving medium sized ephemeral bubbles.	19.0-68	3.05
¹ Castor oil, ² castor oil	Non-frothing, giving a heavy skum of small bubbles.	34.0-73	4.33
Peach kernel	Frothing, small bubbles.	7.0-54	2.86
Castor	Non-frothing, skum like.	20.0-82	3.40
Crude wood turpentine	Frothing, giving an ephemeral small bubble froth.	5.0-61	4.15
Olive oil	Slight skum formed.	3.0-84	2.76
Cottonseed	Small amount of slight bubbles.	5.0-67	3.00-2.71
Corn oil	Practically inactive.	No	3.00-2.6
Soya bean oil	Practically inactive.	No	2.96
Rosin oil	Heavy stiff froth.	22.0-37	2.85
Black grease	Frothing, giving large stiff bubbles.	16.0-23	3.12-2.78
Oleic acid	Frothing, giving large stiff bubbles.	77-13	2.7-2.35
Sperm oil	Thin film formed.	4.0-55	2.90
Cod liver oil	Thin film formed.	3.0-58	2.85
Lubricating oil	Thin film formed.	1.0-22	2.6-2.15
Crude petroleum	Thin film formed.	3.0-36	2.28
Water gas tar	Inactive, failed to emulsify.	No	2.78
Coal tar	Inactive, failed to emulsify.	No	3.49

The flotation tests were made in a modified Hoover machine, the capacity of which was 4000 grams of water and 800 grams of ore. The impeller gave 1700 r.p.m.

The ore used was a dolomitic lead ore crushed to pass 80 mesh.

The only variable throughout these tests was the kind of oil.

The behavior of the oil under test was observed and its flotation value calculated. The flotation value is defined as the weight of concentrate and the metal content obtained in a run of 20 minutes. For example, oil of citronella has a flotation value of 30.0-74, which means that in a 20-minute run 30.0 grams of concentrate was obtained, which analyzed 74 per cent lead. No attempt was made to determine the total extraction, the idea being to get relative results under the same conditions.

The above data indicates that of the oils tested those with a high dielectric constant gave the best results. Oil of orange peel and oil of lemon are exceptions to this statement.

CHARLES Y. CLAYTON.

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Coming Meetings and Events

Joint meeting of N. Y. Section American Electrochemical Society and Illuminating Engineering Society, Engineering Societies Building, New York, Nov. 9.

American Mining Congress, Hotel LaSalle, Chicago, Nov. 13-18.

American Society of Mechanical Engineers, New York, Dec. 5-8.

American Association for the Advancement of Science meets with American Chemical Society and also with the four national engineering societies represented at the Engineering Societies Building, New York, Christmas week, 1916.

American Institute of Chemical Engineers, New York, Jan. 10-13, 1917.

Revision of Chemical Statistics

Joint Meeting of New York Sections of American Chemical Society, American Electrochemical Society and Society of Chemical Industry

The first meeting of the season of the New York Section of the American Chemical Society was held jointly with the New York sections of the American Electrochemical Society and the Society of Chemical Industry in Rumford Hall, Chemists' Club, Friday evening, Oct. 13. The subject under discussion was "Revision of Our Chemical Statistics." Dr. J. MERRITT MATTHEWS, chairman of the New York Section of the American Chemical Society, presided. It being the first meeting of the season the chairman gave a short address in which he discussed several aspects of pure and applied chemistry and their relation to the society and the public.

He said there is a growing tendency to take up technical chemistry in the American Chemical Society, to a greater extent than heretofore. To the layman the study of pure science is but a useless occupation and unless of immediate practical benefit it is considered to be of no value. Discussing the advancement of chemistry, Dr. Matthews said that on one hand we have pure science being worked out in the laboratory with no thought of practical application. He questioned whether this did not seem a little out of the sphere of human interest. On the other hand, pure science is essentially a science of culture, furnishing excellent mind training and in this respect it is all important. He cited the example of Galvani's study of the twitching of the frog's legs which years later led to the great discoveries of electricity. There is not a fact or theory which is developed which does not help some one in some measure. Dr. Matthews thought we are apt to depreciate pure science, in the present age of commercialism. Specialized knowledge in one branch of industry is the main thing at present. Our motto is becoming "It pays to know." He said we are realizing a greater dignity for science as a profession and not as a mere diversion. In the past two years there has been a better appreciation by the press and public, but there is still the idea that chemistry is a hodge podge of mysterious ideas. Chemistry is, however, becoming more and more a part of our human life, and the public interest shown during the recent exposition was very encouraging.

Following Dr. Matthews' address the report of the Press and Publicity Committee appointed for the recent New York meeting was read by Dr. Allen Rogers, chairman of the committee. This committee did a large amount of publicity work in connection with the New York meeting during the recent Exposition week. An office was maintained at the Chemists' Club at which an average of twenty reporters called daily. By making use of a clipping bureau material which was published was clipped out and sent to the committee. About 1000 clippings were returned from 290 newspapers in 164 cities and 41 states. After the reading of the above report Dr. Berolzheimer and Dr. Bogert expressed great appreciation of the work done by this Publicity Committee.

In the line of general business Dr. Hesse introduced a motion that the executive committee be requested to examine into the desirability of a closer coordination of the various sections of the Chemical Society on questions of public interest. He said that in the case of the recent dyestuff tariff, many people were of the opinion that the recommendations made by the New York Section were representative of the whole society. The motion was passed.

A committee consisting of Messrs. Whitaker, Metzger, and Berolzheimer was appointed by the chairman to assist with the work on chemical statistics. He also made the announcement that the suggestion had been made to establish an exhibit of new products made in this country since the war began, at the American Museum of Natural History. Any one having any products to exhibit should bring them to the attention of Drs. Fink, Alexander or Matthews, the respective chairmen of the New York Sections of the American Electrochemical Society, Society of Chemical Industry and American Chemical Society.

The paper of the evening, "The Revision of Our Chemical Statistics," was then read by Dr. Bernard C. Hesse. This is printed in full elsewhere in this issue.

The discussion was opened by Dr. Matthews, who said that one obstacle which presented itself was the narrow-minded attitude of the chemist. He said statistics form the basis of further expansion of our chemical industries, and anyone who has been interested during the past two years in the development of new products has encountered the difficulty of obtaining accurate statistics as to the amount imported and consumed.

Dr. Bogert thought the national committee on industrial preparedness of the Naval Consulting Board ought to be able to help the committee on statistics of which Dr. Hesse is chairman. The National Research Council could also help.

In reply to a question as to how the foreign lists were made up Dr. Hesse said as a rule they try to tell themselves as much as possible about their own business and tell the other fellow as little as possible. For this reason export statistics are not so finely divided as import statistics.

Dr. Herman A. Metz said that statistics were a fine thing and were badly needed and that the colors should be grouped under various headings. He said if these statistics had been available, many who went into the dye industry would have stayed out when they found out how little was really used. He was strongly opposed to publishing the importer's name with the statistics, as he said the amount imported by each firm and the price they pay are "stock in trade" and should not be given out.

Dr. H. A. Huston of the German Kali Works thought discretion should be used in publishing the reports, in order to get the confidence of the importers. He said that government statistics as furnished at present often do not agree with the importers' statistics. The matter of revision should be taken up through the sub-committees of the House and Senate furnishing these sub-committees with accurate technical advice. He said that his company had been very liberal in furnishing statistics and that many inquiries had been made. An interesting part of his discussion dealt with the report of the Federal Trade Commission on the fertilizer industry. He said if the statistics contemplated were going to be anything like that it would dampen everyone's enthusiasm for statistics. This report analyzed the fertilizer industry, discussing the companies in succession and giving all the inside details of each company's operations.

Mr. Metz said that in the recent shipment of dyes to this country on the submarine, Germany didn't publish detailed statistics as to how much each company received. Totals only were given out.

Dr. Alexander said that domestic statistics should be published to complement the import statistics.

Dr. Hesse thought it was too big a job to tackle at one time and that efforts should be concentrated at first on obtaining adequate import statistics, then exports could be taken up, then domestic statistics.

The Iron and Steel Market

October has been a strenuous month in the iron and steel markets. The increased activity that became perceptible early in August in both pig iron and steel products, and was somewhat accentuated in the second half of September, has reached proportions not altogether incomparable with the extreme activity of the late months of last year and the early months of this year. The unprecedented has occurred. After a period of practically stationary prices in both pig iron and steel fresh and important advances are occurring. In all the history of the trade there had been so such performance. Upward market movements have always been separated by periods of market stagnation and great price declines.

Using a weighted average for the common steel products, bars, plates, shapes, wire, pipe, sheets and tin plate, a sketch may be made of the steel movement from the low point at the end of 1914 to the present time. In the first nine months of 1915 there was an advance of about \$5 a ton, while the advance in the last three months was no less than \$8. In the first three months of this year the advance was fully \$12 a ton, this period representing the culmination of the general movement. In the next six months advances averaged less than \$1 per ton per month, but October has shown advances of fully \$3 a ton. So involved has the situation become, however, that price comparisons that could be made with confidence earlier in this movement must now involve assumptions, almost guesses, because the pressure for material is so great and the mills are so burdened with orders that the market is not clearly defined. In many cases they name certain prices as representing their view of "the market" but when offered an order at the price they decline to accept.

The Course of Pig Iron

Using a weighted average to represent the different descriptions of pig iron in different markets, one starts with a low point at the end of 1914, but not until late in July, 1915, was there any general disposition in the market to advance. In the closing months of the year there was a total advance of about \$4.50. Slight advances and subsequent declines left it that at the close of August prices were not higher than at the opening of the year. Now, much the same as in 1915, an advance is in progress, carrying prices up more than 50 cents a ton in September and more than \$2 a ton in October. The course the pig iron market followed in 1915 is readily explained. Demand was increasing steadily during the first half of the year, but idle furnaces were continually being blown in whereby increased demand was met at each successive point by increased supply. Finally, as the less fit furnaces were brought into blast, with higher costs, the market responded to further increases in demand. This year, with prices quite profitable and furnaces tempted continually to sell far ahead, the market lacked a definite force to advance it, until in the past two months there arose fear that an actual shortage might be developed. As the buyers, or at least the steel works, are financially able to pay almost any price for pig iron there has been nothing to hold prices down once the furnacemen acquired the habit of advancing their quotations. Whether or not a shortage will develop cannot be predicted, but some signs have appeared in the past fortnight of there being a scarcity of spot iron.

The Steel Mill Attitude

The steel mills expect the war to last another twelve-month. In the past two or three weeks they have received additional orders for shell steel both for early

delivery and for delivery to the middle of next year, while at the same time inquiry has begun to appear for second half deliveries. With the business that must be carried over from this year because the mills are behind in deliveries the large mills and many of the small mills are obligated for a tonnage almost equal to their production to the middle of next year, this statement referring to the general average, while as some commodities are never sold very far ahead there are others in which the obligations would carry the mills almost through 1917.

The attitude of the mills has been to take care of their regular customers as well as possible, by giving them contracts, subject to specification in future, but by this time such protection has been given in nearly all instances for as great a distance ahead as it is considered desirable to sell. Many of these contracts are accepted with the understanding that in case of a decline in the market, as in the event of the war ending, the buyer will be protected. The contract business is nearly all done, for the time being, while there remains a large demand for steel for specific jobs, in ship and car building, etc. The mills are willing, of course, to accept orders for delivery any distance ahead provided it is assured that the material will be taken irrespective of market conditions. As there is no occasion to protect buyers who are not regular customers the disposition is to advance prices. The mill attitude is much the same as that occupied early this year, when it was not expected that there would be much more buying and the mills advanced prices in the expectation that thereby their order books would eventually be cleared. The outcome was otherwise, and such may be the case again, but the common view of producers probably is that this wonderful movement in steel will come to an end about a twelvemonth hence, and then will follow the extremely drastic readjustment that has been recognized all along as unavoidable.

Non-Ferrous Metal Market

Oct. 26.—There has been comparatively little change in copper prices during the last two weeks, the market being quiet but firm. Lead is unchanged but the market has been more active. Spelter has advanced on a larger demand and tin has also advanced, although the market has been quiet.

Copper.—The copper market has been very quiet but prices hold very firm. Second hands are offering but small amounts for delivery during the balance of the year. The large producers are doing business for the first half of 1917. Lake copper for November and December delivery is quoted at 28½ cents, with electrolytic at 28½ cents for prompt and November and 28 cents for December. January and first quarter electrolytic is 26½ to 27 cents, while second quarter is offered at 26½ to 27 cents. Exports in tons of 2240 pounds up to Oct. 24 were 21,681 tons.

Tin.—Business in tin has been generally dull during the past two weeks, although the market is strong, and prices have advanced ½ cent to 41.70 for prompt deliveries. So far this month only 2005 tons has been received from foreign sources, and there is an increasing difficulty in getting shipping permits from England, who practically controls the shipping situation. This grip could be tightened at any time and the shortage would be keenly felt here. The advisability of carrying large stocks is apparent. Some authorities predict higher prices for next year and also expect England to place an export duty on tin. Prompt Straits is quoted at 41.70 cents, with futures at a slightly higher figure. Speculation in tin in England has practically ceased.

Lead.—The lead market is very strong and the demand is heavy, although the buying has not been exceptionally active during the past two weeks. This is probably due to the sold up condition of the market. The New York quotation by the trust is still 7.00 cents, with independents asking 7.00 to 7.12½ cents. Chemical lead is in excellent demand and considerable of it has been purchased lately. Exports so far this month have been 2817 tons.

Spelter.—A fair business has been done in spelter during the past two weeks and the market is stronger with prices higher during the last few days. Producers are not offering any great amount in spite of the good demand especially noticeable on Oct. 23, when the market was flooded with inquiries from the galvanizing trade. Prompt spelter is quoted at 10.17½ to 10.42½ New York and 10.00 to 10.25 East St. Louis. Exports so far this month are 7027 long tons.

Other Metals.—*Aluminium* is quoted at 64 to 66c. for No. 1 virgin metal. *Antimony* is quiet after a three weeks period of buying by Canadian interests, which stimulated the market and advanced prices. Prompt Chinese and Japanese is quoted at 13.25 cents. *Magnesium*, 99 per cent is held at \$3.50 per lb., and electrolytic *nickel* at 50 cents. *Cadmium* is quoted at \$1.50 per lb., *quicksilver* at \$80 per flask, *platinum* at \$90 per oz., *cobalt* at \$1.25 per lb. and *silver* at 67½¢.

The Western Metallurgical Field

Mills

Within the next sixty days the plant of the **Tintic Milling Company** at Silver City, Utah, will be brought up to its capacity of 300 tons per day. The mill at the present time is handling eighty-five tons per day. Eight new Holt-Dern roasters will be installed of which six have arrived at the property, the other two arriving in the near future. This will materially decrease the cost of production and metallurgists, which have visited the mill, claim that the problem of treatment of the low-grade, siliceous, copper-silver ores of the Tintic district has been solved at this plant.

The number of mills of the Porcupine District, Canada, will be increased in the near future by the new mill of the Foley-O'Brien. The management at the present time is considering the plans for the mill, the foundation of which will be laid before winter. The mill capacity will be 150 to 200 tons per day. Both stamps and mills are being considered.

Recovering Values in Big Mine Dumps

The problem of recovering the values from extensive and old mine dumps is becoming of more and more interest in the field of metallurgy. This is due to the fact that rich ores are becoming more scarce and as some of the old dumps carry as much or more values as the low-grade ores treated, the solving of this problem is of paramount interest.

At Georgetown, Col., a testing plant is in operation running tests on the dump of the **Colorado Central**. Detailed results are not available as yet, but one of the main features is the hand sorting of the material down to one inch in size. The test mill uses a Dodge crusher, trommels, pocket feeders, one to five compartment jig, three Wilfley tables, three Richards pulsator classifiers, one Deister table for the slimes and a flotation machine. According to an authority the experimental work is progressing satisfactorily and a mill will be in operation in the near future. The dump contains 300,000 tons of low-grade lead, copper, silver ore.

Experiments on the dump of the property of the **Colorado-Utah Mines Company** at Lake City, Col., have shown that the dump can be economically treated. The dump contains about 75,000 tons of material. The values of the fills in the old stopes can also be recovered. The management has decided to install finer grinding machinery and recover the values by flotation. This will increase the tonnage treated per day. The present-day practice is to concentrate the ore on tables and to treat the table fines by flotation. The table concentrates run 0.5 per cent copper, 8.6 per cent lead, 47 ounces of silver and 1.4 ounces of gold per ton of concentrates. There are two grades of flotation concentrates, one running 1.65 per cent copper, 2.3 per cent lead, 38.2 ounces silver and 0.57 of an ounce of gold; the other carries 7.3 per cent copper, 21 per cent lead, 81.32 ounces of silver and 1.68 ounces gold per ton of concentrates.

The Hill City Tungsten Production Plant

On Sept. 1, the **Hill City Tungsten Production Company** at Hill City, S. D., started taking custom ores. This mill is the largest one built up to date, the Clark mill at Boulder, Col., being the second largest. The Clark mill handles 75 tons per day, while the Hill City plant treats 150 tons. The power plant consists of two 100-hp. boilers equipped with automatic stokers for burning slacked coal. All the machinery is electrically driven, both at the mine and at the mill by a 90-k.w. generator.

The ore is delivered into a 1000-ton storage bin by the C. B. & Q. Railroad; from here the ore passes to the head bin in the mill. The ore is reduced in three steps: first in a jaw crusher; second by a 30x14-inch roll. Screens are used between the crushing apparatus to remove ore which needs no further reduction. The ore then passes through a Vezin sampler, which takes 1-100 cut for assay. The reject is conveyed by means of a 60-ft. conveyor to a 150-ton storage bin. This bin is located above the concentrating room and holds enough ore for one day's run, so that the mill will not be shut down if any repairing has to be done in the crushing department. By means of an automatic feed the ore is conducted to a pneumatic jig, which removes the coarse mica before the ore is wetted. This latter arrangement solves the troublesome mica problem, which previous to this time made the working of the ores difficult.

From the pneumatic jig the ore passes through eight sizing screens. First, the material passes through revolving trommels; second, a duplex Callow screen; third, through duplicate Bunker Hill screens, and finally through a Callow cone classifier. This combination is probably the most elaborate screening system used. It was decided on this method after three months' trial at the mill of the Black Hills Tungsten Mining Company at Hill City.

The secret of high recovery of tungsten lies in the treatment of the middlings. Experimental work has shown that close sizing only would avail. The ore therefore is divided into the following sizes necessitating the passing through rings 3-5, 5-8, 8-16, 16-24, 24-40, 40-80, 80-200 and through 200. The first two go to two jigs; the third to the sixth, inclusive to Wilfley tables; the seventh to a Deister-Overstrom slimer and the eighth to the flotation plant. The middlings from the first three are reduced to 29 mesh in a 14 x 30 roll; those of the fourth to the sixth inclusive are reduced to 80 mesh in a National disc pulverizer and the middlings from the remainder are reduced to size in a 4½-foot ball mill. All the re-

ground products are pumped back on the duplex Cal-low screens, where they are again sized and sent to the tables with the original ore stream.

The treatment of the middlings consists in taking a large portion from the finer tables and treating it in a flotation plant, and on canvas, 1080 ft. of which has been installed.

The mill is adaptable to any type of custom ore. The three regrinding units have been installed so as to take care of any middling problem which may occur. They will be used on refractory ores only.

The outstanding features showing the high efficiency obtained are close sizing with duplicate screens below 16 mesh to prevent stops for repairs, the regrinding system with duplicate pumps, etc., the treatment of tails by flotation and canvas and the use of three-coarse crushing units, with intermediate screens to prevent sliming.

Company Reports

The annual report of the **Temiskaming Mining Company** for the year 1915, ending with December 31, shows the treatment of 26,927 tons of ore at the mill, producing 390.85 tons of concentrates. The silver recovered from the mill concentrates was 509,073.62 ounces. The actual production for the year was 1,456,894 ounces of silver shipped. The cost of production was 16 cents per ounce. The high-grade averaged 6413 ounces of silver to the ton and the mill concentrates averaged 1302 ounces to the ton.

The first annual report of the **Schumacher Gold Mines, Ltd.**, to June 30, 1916, shows ore reserves of 64,900 tons, valued at \$396,700, averaging \$6.11 per ton. The plant consists of the following: Compressor building, containing two electrically driven air compressors, delivering 1500 cu. ft. free air per minute; two 135-hp. boilers and one double-drum Jenckes hoist, a fully equipped blacksmith shop, shaft houses with two cages, new office buildings, a complete assay office, refinery, mine manager's bungalow, thaw house, pumping station with a 3-in. water line, mill of the continuous decantation-type, with a capacity of 150 tons per day, and other smaller buildings.

The mill has been in operation since the middle of September, 1915. The results obtained from Oct. 1, 1915, to June 30, 1916, are as follows:

Month	Tons Milled	Operating Cost	Cost per Ton	Bullion Production	Production per Ton	Net Profit for Month	Profit per Ton
October, 1915	2,355	\$11,365	\$11.44	\$2	\$16,703.24	\$7.09	\$5,338.13
November	2,570	13,416	47.22	14,261.10	5.54	844.63	0.32
December	2,940	13,345	31.55	14,527.20	4.98	1,011.89	0.34
January, 1916	2,880	14,665	93.54	13,663.78	4.88	*1,000.15	*0.36
February	2,940	14,825	42.56	14,983.99	5.07	139.57	0.05
March	4,020	16,780	29.47	19,919.09	4.95	3,118.80	0.78
April	4,130	15,971	83.36	22,341.95	5.41	6,370.12	1.55
May	4,225	15,322	86.32	21,188.84	5.01	5,865.98	1.39
June	4,100	15,850	20.36	24,379.82	5.94	8,320.02	2.08
	30,120	\$131,719.42	....	\$161,949.01	....	\$30,229.59	....
Interest		340.03	....				
Depreciation			....	212.50	....		
Cost of consumables			....	2.19	....		
Sold to the public			....	1,828.50	....		1,703.16
	30,120	\$132,059.45	....	\$162,962.20	....	\$31,932.75	....

*Loss

It will be observed that in spite of the rapid and continued rise in the cost of the supplies, a marked reduction in the operating costs was made in the latter part of the year ending with June 30, 1916. While the cost per ton for the first five months ending with Feb. 29, 1916, was \$4.96, the average cost for the four months ending with June 30, 1916, was \$3.88. The net profit for the former period was \$6,325.07, while for the latter it was \$23,904.52.

Development of Our Potash Industry*

By F. M. deBeers

President Swenson Evaporator Co.

American chemists have been looking for potash in this country for a great many years, and several deposits and sources were discovered years ago and then neglected by capital because of the moderate price of the German article. Most, if not all, of the present sources were known before the war, but the industry did not seem then to promise returns large enough to warrant the hazard of the new undertaking. Consequently nothing was done until our supply was suddenly cut off, and a brief review here of what we bought on the average per year from Germany may not be out of place.

In round figures the following list shows approximately what we imported each year:

	Tons
Potassium muriate (80%)	250,000
Potassium sulphate (90%)	50,000
Manure salts (20-38%)	200,000
Kainit (12-15%)	500,000
Total	1,000,000

Figuring all the potash as K_2O or potassium oxide would show about 360,000 tons of the oxide in the above importation. Our yearly supply of German potash cost us about \$20,000,000 before the war. During the balance of this paper when I refer to percentage of potash I will mean per cent of potassium oxide or K_2O .

The question of whether we can produce this large amount of potash here and take care of our increasing demand is entirely too large for me to even consider, particularly as no one seems to know when the war will end and what Germany plans to do then. We know she can produce potash very cheaply, and we also know we have large but scattered supplies of potash-bearing materials here, but the whole thing is in too primitive a state now to warrant any guesses. Some of our present developments will survive any competition, but others are simply intended to fill a present demand.

In this paper I am only attempting to explain where we can secure our raw potash salts and what has been done up to the present that has come to my notice. The refining and purification of these raw salts has been done here before the war, and our large chemical companies can without doubt take care of this phase of the situation. Some of these raw salts can, of course, be used in their raw state in certain industries. Most of my information is first hand, and my estimates as to quantities are, of course, approximations. I wish here to say that some of my information was obtained from reports by experts in other industries, and to all these men I acknowledge my indebtedness.

Our sources of supply can be divided into two classes, one containing those which are by-products, and the other class consisting of industries where potash is the principal product. We will consider the by-product potash first.

By-Product Potash

POTASH FROM WOOD ASHES

Wood ashes have been a source of potash ever since our ancestors knew how to use same. After the German industry had developed, the making of potash from ashes was practically abandoned, but lately, I believe, our supply is being augmented from this source.

I have not been able, however, to locate any data that is sufficiently complete and reliable as to what we can expect in total tonnage, etc. I am of the opinion that

*An address made before the American Meat Packers' Association in Cincinnati October 10, 1915.

this source is not of very great importance from a commercial standpoint.

POTASH FROM BITTERN

Bittern produced in the manufacture of salt from sea water, contains potash, but the quantity is very small and it is very difficult to separate from other salts.

Bittern from the water of our Great Salt Lake is now being treated by three companies, and this runs about 2 per cent potash. Each company has its own method of separation and purification, and if they all operate up to their expected capacity they could turn out approximately 30,000 tons of raw salts per year, running about 20 per cent potash. This figure is only approximate, as before stated, but it will serve to show that this source is not very important and high freight rates to Eastern points make it appear as if this process might have a hard time surviving after the war. The bittern also contains about 5 per cent magnesium oxide, and because of same my conclusion may be unfair.

POTASH FROM WOOL

Wool is scoured or washed before it can be made into yarn, and this wash water contains about 3 per cent total solids after the wool, grease and dirt have been separated out. These solids will average over 25 per cent in potash and are easily recovered.

This material is available at the Atlantic seaboard, and because of the value of the wool grease, it is very probable that the manufacture of potash in this way can be commercially successful. Another reason for saving this waste lies in the fact that by doing so this objectionable wash water is not run into streams or sewer systems. While the potash made should be easily marketable, the quantity obtainable from this source cannot be very great, and I regret I have no figures as to tonnage. The potash is in the form of carbonate and potash soaps.

POTASH FROM FISH WATER

Fish water produced in menhaden factories contains about 8 per cent solids, and these solids will average 5 per cent K_2O and over 16 per cent ammonia. This cooking water should be saved and can be converted into a most profitable by-product. The industry is not a large one, however, and not more than 15,000 tons of dry fertilizer averaging as above could be produced per year based on the average kill of our Atlantic factories for the past five years.

POTASH FROM SUGAR FACTORIES

In the making of alcohol from cane molasses, there is a liquid residue left in the still which contains 5 per cent solids. These solids will average 9 to 10 per cent potash and also contain some ammonia. The potash is probably in the form of carbonate and sulphate. A few distilleries are now saving this slop and recovering the potash. If all the slop made in this way were saved and the solids recovered, we could count upon a production of about 200,000 tons of 10 per cent potash per year as a maximum, and I am inclined to believe that this estimate of mine is a little too high.

Many of our beet sugar factories employ the Steffens process for recovering the sugar from their molasses, and after the sugar is made in this way there remains a waste solution averaging about 4 per cent solids. Approximately half our factories have this waste material. These solids can be recovered, and many European factories are doing so, but up to the present time our sugar makers, with a few exceptions, have done nothing.

A dry product made from Steffens water will average over 6 per cent in ammonia and over 12 per cent

in potash in the form of carbonate. Our American farmers will probably produce 7,000,000 tons of beets this year, and if the Steffens process were used in every factory and all the water were saved, we could count on about 200,000 tons of product every year of the above analysis. We are expecting a decided and permanent increase in our production from this source within the next year.

POTASH FROM CEMENT PLANTS

In the manufacture of cement, the dust leaving the furnace carries a considerable quantity of potash salts, and these are being recovered by several methods. The most successful seems to be the Cottrell system, and very large returns are obtained according to several authorities. I have estimated roughly that we could produce about 80,000 tons of potash annually in this way if the figures given me are correct.

It is sufficient to say that several plants are now using this process successfully, and one plant is now being built near Buffalo that will turn out potash as the main product and cement as a by-product. This, of course, is a development of the feldspar situation to be discussed later.

POTASH FROM BLAST-FURNACE GASES

Furnace gases from blast furnaces contain potash due to the volatilizing of the potash salts by the high temperature. This probably produces potassium cyanide, and the amount of potash that passes away is enormous. My own figures seem so large that I am afraid of them, mainly because I have not had any direct experience or contact with this problem.

If the statements of authorities who have written in high-class journals are correct, this is one of our largest sources of potash, and is no doubt being investigated thoroughly (and quietly) by the large producers of pig iron. The dust which settles in the stoves and boilers is now collected and sold to refiners of potash salts, although I could not find any data as to quantity.

Potash the Main Product

This about takes care of the development of our by-products as a source of potash. The remaining sources can be grouped under four headings, kelp, alunite, western lake waters and feldspar. There are some other minerals which contain potash, but personally I have not learned of any which are in sufficient quantity to be considered.

POTASH FROM KELP

The making of potash from kelp is being carried out with partial success on the Pacific Coast. The present high value of this material and the absolute necessity of securing a supply has made it logical for some large users to put up plants for this purpose, and they are good investments no doubt for these reasons.

I cannot see how this can be a permanent industry with potash at the price it was before the war unless some one perfects a process that will permit of a lower cost of production. This, of course, is only my private opinion, and I hope I am wrong, which is easily possible, as I have not had the opportunity to study the matter as closely as I would like to. If the kelp is thoroughly dried or burned, I am told it is possible to secure a product running over 15 per cent potash. So far as I know, no figures are obtainable as to production.

POTASH FROM ALUNITE

Potash from alunite is being successfully made in Utah and I believe this industry is a permanent one. One of our large packers is responsible for the first commercial plant and I am told that outside of the set-

backs which must be expected in such a new development, the process is a success.

According to my own figures which are simply estimates, I would say that the production next year should be at least 20,000 tons of potassium sulphate 90 per cent pure—a very high-grade product.

Other plants are now being contemplated and we may soon have a much larger output. The ore itself runs from 8 to 12 per cent in potash and the process of manufacture is relatively simple.

POTASH FROM WESTERN LAKE WATERS

The largest source available for quick use is out in Western Nebraska and Wyoming. This field to my way of thinking is also a permanent one and after the business has been standardized and the necessary experience secured, I believe our Nebraska friends can compete, if necessary, with Germany within a reasonable shipping radius.

There are a large number of these small lakes running from a few acres up to several hundred acres apiece. Those containing potash salts have vegetation around their banks, while the alkali or soda lakes are barren. You will very often find two lakes side by side with potash in one and not in the other.

Experts are now at work trying to locate the source of the potash that drains into these ponds and if they are successful, we will probably be relieved of any worry as regards our supply. These lakes or ponds will average 10 to 15 per cent total solids and these solids when dried will contain from 15 to 30 per cent potash depending upon which lake is being worked. A fair average would be $12\frac{1}{2}$ per cent solids containing 20 per cent potash.

One small lake alone which is being worked now is said to contain over 300,000 tons of these salts. A large number of lakes have been bought and will be developed as soon as the new plants can be finished. It should not cost over \$5 per ton to make the final dry product and this allows liberally for every item of cost so it will be understood why I say that this field should be permanent at least for a good many years before the lakes are drained. I should say that by the first of next January, we will be getting 20 per cent potash salts from this district at the rate of 100,000 tons per year as a minimum.

Oregon has several lakes that contain very large quantities of potash as sulphates and carbonates. Some work is being done, but so far as I know, there have not been any developments on a commercial scale up to the present time. I learned of one lake recently that I am told contains 18 per cent total solids of which 8 per cent is potassium carbonate which certainly sounds very interesting.

Searles Lake in California contains a large quantity of potash and a great deal of money has been and is being spent to produce a marketable product. The problem is not an easy one as the brine contains a mixture of potassium and sodium sulphate, carbonates, chlorides and borates. They are very hard to separate, although I know that several hundred thousand dollars has been spent on a plant within the last year by the American Trona Corporation which anticipates a large tonnage of potash salts soon. The brine used contains over 30 per cent total solids with about 5 per cent of potassium chloride. The company is figuring on an output of 40,000 tons per year of 80 per cent muriate and so far as supply is concerned, they could operate at many times that rate for years to come as the lake is very large.

POTASH FROM FELDSPAR

Feldspar occurs in so many localities that we are all hoping that some American chemist will soon solve the

problem of how to make potash from same on a commercial scale. The supply is practically unlimited. It averages from 8 to 15 per cent potash in the form of silicate and aluminate.

One syndicate of miners in Colorado is producing 2000 tons of finely ground and washed feldspar each day which is all ready for a satisfactory process.

Hundreds are experimenting and if I had time I would be glad to explain some of the methods being tried. As soon as an economical method is discovered, we need have no fear about our supply, but such a method must be able to produce at a cost comparable with Germany's cost, which up to the present time has not been done to the best of my knowledge.

CONCLUSION

I have not attempted to explain any particular process used in making potash from any of these raw materials as such information to be complete would result in a book, rather than a paper. After studying this question as carefully as possible, I am of the opinion that we will produce raw potash salts next year in sufficient quantity to supply about one-third of our average demand before the war or equivalent to 120,000 tons figured as potassium oxide (K_2O).

There is a chance that we may exceed this by 50 per cent if certain properties are worked or if new processes are developed, but even then we would have but half our requirements during normal times and right now we could really use more than that. Our future as a large producer depends entirely, to my way of thinking, on our success with feldspar, alunite, blast furnace gases, Searles Lake, and other lakes in Nebraska, Wyoming and Oregon. We cannot secure much more than about 15 per cent of our requirements from the by-products first discussed, although many of these should be permanently profitable.

Chicago, Ill.

American Electrochemical Society's Next Year's Meetings

The 1917 spring meeting of the American Electrochemical Society will be held in Detroit and the autumn meeting in Pittsburgh. No definite dates have yet been fixed.

Chemistry of Gas Lighting

The New York sections of the American Electrochemical Society and the Illuminating Engineering Society have arranged for a joint session to be held at the Engineering Societies' Building, 29 West Thirty-ninth Street, New York, on Thursday evening, at 8 o'clock, Nov. 9.

A very attractive program has been prepared, including papers by E. L. Knoedler of the Welsbach Company on "The Most Recent Developments in Incandescent Gas Mantles," and W. R. Addicks, vice-president of the Consolidated Gas Company of New York, on "Some Notes on Gas Standards."

The October issue of the *General Chemical Bulletin*, the house organ of the General Chemical Co., contains much that is interesting concerning the activities at the various plants of the company. Considerable space is devoted to safety and general welfare work and to athletic activities, and there are also some technical news of more than passing interest. This well edited Bulletin is a credit to the company.

The *Electron Chemical Company* of Portland, Me., manufacturers of the Allen-Moore electrolytic cell have opened a New York office in the Woolworth Building.

Glimpses of New Pacific Coast Industries in the Making

Impressions from a Flying Editorial Trip to California

(Concluded from page 288)

CHEMISTRY IN SOUTHERN CALIFORNIA

It has been said that Los Angeles, Southern California's metropolis and the home of the cafeteria and the jitney, has only one highly developed industry: real estate. Truly if California is famous for her boosters, the real estate boomers of Southern California must be mentioned in the front rank. Talk with any one you meet in Los Angeles, be he a bank president or an oil engineer or a sugar man or a hotel clerk or whatever else, and inquire about real estate, you will find at once cordial attention. Whatever else they may do in life, they are all, each in his or her big or little way, interested in real estate and willing to sell you lots. And if you are daring enough to drop a word about the quoted prices of the lots, you will be quickly and convincingly told that God's country is limited in area and that the demand is increasing and that according to the law of supply and demand everything is as it should be.

In a country that depends so directly and almost exclusively on the products of its virgin soil, it is clear that industrial chemistry can play an important part only in a limited way in a limited number of industries. In Southern California it is chiefly in connection with the immense oil and gas industry and the beet sugar industry that chemists have become indispensable. This has been so for years and their importance is increasing. At Oxnard, not far from Santa Barbara, is the largest beet sugar factory in the world. And everyone knows what the oil wells mean to Southern California—and to the automobilists of the whole country.

Yet in this comparatively simple wave form of chemical activity, with its two fundamentals of oil and gas and of sugar, overtones are becoming distinctly audible. Last year we commented on the admirably progressive work of the Kieselguhr Company of America at their mine and mill at Lompoc in Santa Barbara County; here again Californian soil offers directly something extraordinary, an infusorial earth of very unusual purity; but its utilization in the industries in the form of silocel for heat insulation and in the form of filtercel for filtration in many fields has required and is requiring very extended chemical research work. It is a pleasure to state that ever increasing success crowns the persistent efforts of this American pioneer industry.

During this year's trip a new theme was predominant in many variations—potash. But before we take up this subject we must mention some electrochemical developments. In some way their existence was rather unexpected.

ELECTROCHEMISTRY AT LOS ANGELES

For large-scale electrochemical developments in which large amounts of electric power are required, Southern California, which derives 50 per cent of its present electric central-station generating capacity from water-power and the other 50 per cent from steam, is not so lavishly favored by nature as Northern California with its large amount of hydro-electric power developed and awaiting development under rather favorable conditions. But whether it is on account of the labor situation—the difference between union-ridden San Francisco and open-shop Los Angeles—or just accidental, in one line of electrochemical endeavor at least, that is the use of the electric furnace in the steel industry, Los Angeles is ahead of San Francisco.

At Redondo there are several electric steel furnaces, consuming in the whole 800 hp. The original American Stassano furnace installation at this place was described in our Vol. XI, p. 709.

Then the Ford Motor Car concern uses electric baking and enameling furnaces consuming 600 hp.

An installation of 150 hp., producing oxygen and hydrogen by electrolysis of water, may be mentioned in the same connection, as it is used for welding and cutting purposes in the steel industry.

It was rather gratifying and certainly interesting to learn from Mr. S. M. Kennedy, general agent of the Southern California Edison Company, that his company had received in the recent past numerous inquiries from Eastern concerns on rates for power.

To conclude the notes on electrochemical developments as well as to introduce the subject of potash, it is our pleasure to say something of a very enjoyable visit to the Western Precipitation Company's laboratories at Los Angeles.

WESTERN PRECIPITATION COMPANY

This company for chemical and metallurgical engineering research is itself one of the most interesting developments of chemistry in California. It is unique no less in origin and scope than in the arrangement of the building. This is built according to the ideas of its genial general manager, Mr. Walter A. Schmidt, as a square with a square court or garden in the center. The four surrounding buildings, all interconnected, serve as office building and laboratories. From all of them a free view is had of the central court; it is really very pretty and below the ever-blue sky of Southern California this ever-green garden is a continuous source of inspiration to the workers in the laboratories. The accompanying photograph shows just one corner of the central court.

The Western Precipitation Company is electrochemical in origin, being an outgrowth of the electrostatic fume and dust precipitation process of Dr. Cottrell, California's greatest contribution to electrochemistry and electrometallurgy. In promoting the Cottrell process and introducing it into practice, the Western Precipitation Company has paid special attention to dust recovery in cement mills.



JUST A CORNER IN THE CENTRAL COURT OF WESTERN PRECIPITATION COMPANY'S LABORATORIES



FIG. 1—ONE OF THE HARVESTER BARGES, LORNE MANUFACTURING COMPANY, LONG BEACH, CAL.

Its pioneer plant in this field is at the Riverside Portland Cement Company at Riverside, Cal. The process was installed there originally as a protective measure—to prevent the orange groves in the neighborhood from being damaged by cement dust. But it was found then that the dust recovered could be made a source of potash; although the percentage of potash in the raw mix was only 0.2, the dust recovered contained potash in quantities which made it worth while recovering, and such recovery is now made.

While it is in a certain measure a war baby, yet this development is bound to stay after the war is over. Figures shown to us by Mr. Schmidt of the amounts of potash which may be recovered in this way from cement mills, are very encouraging. It is certainly significant that the Security Cement & Lime Company at Hagerstown, Maryland, has installed the same system under license of the Western Precipitation Company and is now recovering potash on a commercial scale.

But we would not do justice to the Western Precipitation Company's work, if we only spoke of their connection with the Cottrell process and potash recovery. The scope of their work is very much wider and comprises practically the whole of chemical and metallurgical engineering. To mention only two very extended researches carried out at the laboratories, one has to do with an important phase of sulphuric acid manufacture, a second one with the problem of leaching copper and other ores. While the main offices of the company are at Los Angeles, it has branch offices at Philadelphia, Vancouver, B. C., Frankfurt on Main, Germany, Lon-



FIG. 2—KELP DROPPING OFF THE CONVEYOR ON TO THE BARGE—THE BLACK SPOTS IN THE WATER ARE KELP GROVES

don, England; Melbourne, Australia; Santiago, Chile, and Yokohama, Japan.

POTASH

But the Western Precipitation Company is by no means alone in Southern California in endeavoring to find a solution of the potash problem.

The Searles Lake scheme on which a great deal of money has been spent, is progressing further and it is hoped that finally a solution of the rather difficult problem of separating the various potassium and sodium salts in a commercial and economic process will be found. When that is the case, Searles Lake will be an important source of supply of potash.

But other sources of potash are by no means neglected as we learned from Mr. Edgar Baruch, chemical engineer of Los Angeles. One of the latest developments, still in the state of evolution at the time of our visit, is the recovery of potash in sugar plants.

But most attention is probably paid to the recovery of potash from kelp or seaweed. As a general review of the various endeavors in this line with a brief sketch of the different companies was given in our issue of April 1, 1916, (Vol. XIV, p. 355), reference may be had to that article. We will give here only a sketch of the American Products Company or Lorne Manufacturing Company at Long Beach, where we spent a very enjoyable forenoon. By the way, it has been said—we will not argue with how much truth—that Los Angeles itself is in many respects but an outgrown town, but then it must be added—and there is no doubt of the truth—



FIG. 3—PRE-COOKER FOR SEPARATING SALT-BEARING LIQUOR FROM PULPY MATTER (NOT IN USE IN NEW PROCESS)



FIG. 4—HARVESTER IN KELP FIELD, LORNE MANUFACTURING COMPANY, LONG BEACH, CAL.

that the redeeming feature is the lively spirit of her many beaches.

PLANT OF AMERICAN PRODUCTS COMPANY

The American Products Company, with rather extended works at Long Beach, has been largely financed by Mr. G. W. Simmons, vice-president of the Simmons Hardware Company of St. Louis, Mo. The development of the process in operation is interesting and in a sense typical.

The process originally used by the American Products Company was that of Mr. Isaac Naylor. The characteristic feature was that the potash salts were extracted from the seaweeds, without burning them up, so that in addition to the potash salts, a by-product of cellulose or pulposus matter is obtained which is of itself of sufficient value, thus assuring the profitable operation of a potash plant under normal conditions.

Mr. Naylor had for years been devoting his energies to the creation—from waste materials—of useful articles of commerce. He first manufactured a small barrel from corn-stalks and also from the pulp of sugar cane (known as bagasse). A quantity of these kegs were filled with nails and shipped many thousand miles by rail and water. Not one of them broke or failed to arrive at destination with contents intact.

During his experiments in this fiber process, Mr. Naylor conceived the idea of treating kelp by similar chemical and mechanical methods, as he had used in producing the nail kegs. He succeeded in procuring a pulposus material from which a satisfactory barrel was made and in addition he released the liquid matter of the seaweed containing the potash salts, so that the two products were simultaneously produced. Further experiments developed the fact, however, that this pulposus material still contained from 10 to 12 per cent of potash salts and contained as well more than 2½ per cent of nitrogen and a similar quantity of phosphoric acid. It was, therefore, found that the material commanded a higher market price as the base of a fertilizer than for the construction of barrels or railroad ties or other materials made by the fiber process.

Starting in October, 1915, a complete potash and fertilizer factory was erected at Long Beach and is being operated by the Lorned Manufacturing Company. The plant was first operated by the Naylor process and was producing for a time about five tons daily of high-grade muriate of potash (97 per cent) and as a by-product about 30 tons daily of a potash fertilizer averaging from 12 to 25 per cent of potash with over 2 per cent each of nitrogen and phosphoric acid.

However, in large-scale operation the Naylor process which had worked ideally in the laboratory, proved prohibitive in cost. Being essentially a wet process, the cost of evaporation was too great and the Naylor process in its essential details had to be abandoned.

It is to the great credit of the present general manager of the plant, Mr. Leslie H. Thompson, to have put the plant on a paying basis by a simple radical change. He cut out the whole first steps of the Naylor process and changed the wet process into a dry process. No by-products are now recovered but all efforts are centered on the direct and most inexpensive production of potash. Three tons of muriate of potash of 97 per cent is the present daily output. Iodine was not yet recovered at the time of our visit, but it was stated that the recovery of iodine would be a simple matter.

This evolution from the complex to the simple is in a way typical. We can repeat here what we said in our first article (Sept. 15, p. 286) concerning the Noble Electric Steel Company: that it is a mistake to try to do too much at once, that the first aim of an operating man

must be to make the operation successful in the main object and as foolproof as possible. The experience of the Lorned Manufacturing Company is new evidence for the correctness of this fundamental operating principle.

Mr. E. J. Porteous is the chemist of the Lorned Manufacturing Company.

Our thanks for courtesies received are due to the general manager, Mr. Leslie H. Thompson and our congratulations on the final success of this pioneer undertaking to him as well as to Mr. G. W. Simmons.

The threatening railway strike prevented our intended visit to the Hercules Powder Company's immense new plant at San Diego.

It is certainly pleasing to watch the enormous activity in the commercial recovery of potash from kelp. Yet while it is right and good to make the most of the kelp that Nature is abundantly providing, we might pay a little attention to a more fundamental problem: In which way are potash and iodine concentrated by Nature in kelp from sea water? What is the character of the semipermeable diaphragm or generally what is the mechanism of the concentration process? If only a partial solution of these questions was found it would be a great step forward.

Current News and Notes

Mining and Metallurgical Society.—At a regular meeting of the New York Section, held on Oct. 19, at the Engineers' Club, Morrill B. Spaulding was elected chairman to fill the office declined by W. R. Ingalls, who was elected at the annual meeting.

General Discussion on Refractories.—The Faraday Society will hold a general discussion on "Refractories" at their first autumn meeting, the date of which is provisionally fixed for Wednesday, Nov. 8, 1916. The discussion will be presided over by Sir Robert Hadfield, president of the Society, and the opening paper will be read by Dr. J. W. Mellor.

Gasoline from Natural Gas.—The output of of casing head gasoline in 1915 was 53 per cent greater than the 1914 output according to the U. S. Geological Survey. The quantity of raw gasoline extracted in 1915 was 65,364,665 gal. The volume of gas used in the manufacture of this gasoline is estimated at 24 billion cubic feet. The number of plants engaged in the industry increased from 386 at the beginning of the year to 414 at the end.

Paper-Making Industry in Russia.—The improvements in the Russian paper-making industry are continuing. A considerable increase in the export of pitprops, wood pulp, etc., from Archangel during 1915 is reported, the quantity being 11,648,755 cu. ft. for 1915, while that for 1914 was 7,285,696 cu. ft. Developments are also taking place in the Siberian paper industry, new plants being under construction at Gorochoff and at Krasnoyarsk or Irkutsk. The I. E. Yatess paper works are being formed into a company; the Volojod and Tver district council are contemplating the erection of a paper factory in the northern timber areas of Siberia and Russia near the town of Taiga. According to reports, the annual paper consumption of Siberia is 36,000 to 54,000 short tons per year. (Commerce Reports, Oct. 10, 1916.)

Census of American Blast Furnaces.—The United States Bureau of Census has made a preliminary statement of the 1914 census of manufactures of blast furnaces in the iron and steel industry. There are 162 establishments reported, employing 33,194 people. The primary horsepower is 1,222,273; the capital involved is \$462,282,000. The cost of the materials

treated is \$264,580,000, and the value of the products obtained is \$317,654,000. The value added to the above by manufacture is \$53,074,000. (Commerce Reports, Oct. 6, 1916.)

Wood Pulp Industry in New Zealand.—The New Zealand Wood Pulp & Paper Manufacturing Co., Ltd., has been incorporated with headquarters at Christchurch. Much developing work is being done and it is expected that the company will turn out 20 to 25 long tons of paper daily. Most of the paper will be turned out in rolls for newspapers. The daily consumption of paper of this type is estimated at 40 tons, and it is believed that all the paper turned out by the above company will find a ready market in the newspaper line. (Commerce Reports, Oct. 5, 1916.)

Graphite and Carbon Electrodes in England.—Up to within very recent times, Great Britain has imported practically all electrodes used in the smelting and refining of iron and its ores from the United States. New installations of a number of electric furnaces at Sheffield have created a greater demand for electrodes. To part way satisfy this growing demand, the Electrode Co., Ltd., of Sheffield, has been organized with a capital of \$243,325, for the manufacture of carbon electrodes, and a plant is under construction which it is expected will be in operation within the next three months.

The promoters of this company are four large manufacturing concerns which have installed or have in process of erection 23 electric furnaces, with a total capacity of 90½ tons. The new company will have an estimated output of from 3000 to 5000 tons of carbon electrodes per year. (Commerce Reports, Oct. 5, 1916.)

D. R. Sperry & Co., Batavia, Ill., have designed and constructed for the new plant of the Armour Fertilizer Works, Chicago, a 54-in. evaporator, barometric condenser, autoclave and wood filter press. An order has been received from Wilson & Company, packers, for eight recessed-plate filter presses for its new plants at Chattanooga, Tenn., and Oklahoma City, Okla.

The Claud S. Gordon Company, formerly of 7415 Vernon Avenue, Chicago, will soon open a new shop at 646 East Seventy-fifth Street, Chicago, which will be used to handle the increased demand for pyrometer service, determination of fusion points and general research work in high temperatures.

Pocket CO. Indicator.—The Bacharach Industrial Instrument Company has issued a pamphlet describing a new flue gas analyzer which has been developed by this company. It is stated to be handy, compact and accurate.

The Cutler-Hammer Manufacturing Co. of Milwaukee, has removed its Cleveland office from its location in the Schofield building to modern and more commodious offices on the twelfth floor of the Guardian building, Euclid Avenue. This is the fourth time since its establishment, seven years ago, that the office in this city has been compelled to double its quarters. G. S. Crane, assistant manager of the central district, continues in charge of the Cleveland division. The central district covers the western half of Pennsylvania, West Virginia and three-quarters of Ohio, with completely equipped sales offices in Cleveland and Pittsburgh. The district is in charge of A. G. Pierce, manager central district, with headquarters in Cleveland and Pittsburgh.

The Doehler Die-Casting Co. announces the removal of its brass-back bearing department from the Brooklyn to the Toledo plant. An entire new factory building, housing foundry and machine shop, fully

equipped with all modern labor-saving devices, is devoted to the manufacture of "Doehler" babbitt-lined brass-back bearings.

Galalith.—Galalith is a bonelike substance, in many respects resembling celluloid. This product is essentially of German origin and has been on the market for several years. It is manufactured from casein by means of formaldehyde. A solution of casein is obtained by treating skimmed milk with caustic alkali or carbonate. This solution is clarified and the casein precipitated by means of acids and then filtered. The water is then partly extracted by pressure and the product dried very slowly. The drying process extends over a period of several weeks. The plates of casein thus obtained are thoroughly saturated with formaldehyde and again submitted to drying. The product is somewhat transparent, of a yellowish-white color and very similar to horn. If a colored or mottled product is desired, coloring matter is added to the casein solution, or powdered cork, soot, wood pulp, earth, etc., are kneaded into the precipitated casein. Acetate of lead is also used for precipitating casein. The specific gravity of galalith is 1.317 to 1.35, and its hardness is 2.5, according to Mohs' scale.

Galalith is an excellent insulating material and may be utilized either in a cold state or after it has been softened in hot water. It is free from odor and is less inflammable than celluloid. It is never absolutely transparent and cannot be manufactured in thin sheets.

The material is becoming of more and more importance, at least in Germany, which is indicated by the fact that Germany is making inquiries in regard to the import of skimmed milk from the United States for the purpose of manufacturing galalith. Small amounts of this product have been shipped to the United States. The figures in terms of dollars were: 1912, \$10,769; 1913, \$12,007; 1914, \$16,395, and for the first six months of 1915, \$6,274. (Commerce Reports, Oct. 10, 1916.)

Sulphur in Wyoming.—The Midwest Sulphur Co. with their property located at Cody, Wyo., has been notified that a cave has been discovered on the Laramie River, two miles from the quarries whose walls are lined with high-grade sulphur, 3½ to 4 ft. in thickness. The cave is approximately 30 ft. in length and 40 ft. in width. The product is an especially pure one, analysis running as high as 99.00 per cent in sulphur. The material may be shipped without further purification.

The Metal Production of New Mexico in 1915.—According to the U. S. Geological Survey the metal production for New Mexico for the year 1915 was \$19,279,368 against \$11,049,932 for 1914. The distribution of the values was as follows: Gold, \$1,461,005; 2,005,531 oz. of silver; 76,788,366 lb. of copper; 4,542,361 lb. of lead and 25,404,064 lb. of zinc. These figures show an increase of \$289,309 in gold, 228,086 oz. of silver, 17,480,441 lb. of copper, 2,778,720 lb. lead and 7,000,672 lb. of zinc. The value of the metals, except silver, was higher than in 1914.

Production of the Dome Mines, Ontario, for September.—The Dome Mines for the month of September treated 38,300 tons of ore, producing \$179,500 in gold. The average value per ton of ore was \$4.886 and the estimated cost \$2.59 per ton, giving an average profit of \$2.09 per ton. These figures show a falling off in production as compared with August. For the latter month the Dome treated 40,100 tons of ore worth \$180,000 at an average value of \$4.49 per ton. The operating costs for August was \$2.56 per ton, \$2.61 for July and \$2.62 for June.

Why Our Chemical Import Statistics Should Be Overhauled*

By Bernhard C. Hesse

On three previous occasions¹ I have pointed out in more or less detail the need of a revision of our chemical import statistics, more particularly to the need of a finer subdivision of the itemization of the entries, and have indicated how this might be accomplished.

Assurances of enthusiastic and sympathetic co-operation have been received from a number of technical and commercial associations and organizations, as well as from the Department of Commerce and from the United States Geological Survey. Many high executive officers of domestic chemical manufacturing and merchandising enterprises have assured me of their belief and faith in the great potential good residing in such an effort, and editors of our leading trade publications, such as the Oil, Paint and Drug Reporter of New York, and the Paint, Oil and Drug Review of Chicago, have in sincere and emphatic editorials seriously commended this endeavor to the thoughtful consideration of their readers, and have urged intelligent and prompt co-operation.

It is, therefore, only reasonable to assume that these proposals bear, on their surface at least, evidence of potential constructive good for the country at large. It now remains for us to realize this supposed potential good. To this end the co-operation of all the sections of the American Electrochemical Society and of the American Chemical Society has been solicited, and there is plenty of evidence of a whole-hearted desire on the part of all to contribute all they can and to co-operate to the extent of their opportunities and ability.

As a result of considerable correspondence with sectional secretaries and of conversations with a number of local councillors during the holding of the Second National Exposition of Chemical Industries last month, it has seemed to me that after all I had not succeeded in clearly bringing out the crux of the situation, so that all were clear as to just what was wanted and as to how it might be done, although quite a number of sectional secretaries did fully get the ideas and suggestions conveyed by my publications and have proceeded accordingly.

In view of the situation as a whole, it may be well to say what are not the objects of this project, since many seem to have obtained enlarged notions of its scope and which would be unworkable.

1. We are not now concerned with exports in any sense.
2. We are not now concerned with prices or quantities in any sense.
3. We are not now concerned with locus of import or consumption.
4. We are not concerned at any time with the names of users or importers.

What we are after is the names, and the names only, of those things that in normal times come to us from abroad and are used by or can be made by a branch of our chemical industry.

For example, what material of construction or what chemical raw materials come to us from abroad which our domestic chemical industry in any branch thereof needs?

What materials that can be made by a branch of our domestic chemical industry are imported?

It must be noted that quantities, prices—unit or

otherwise—and locus of consumption are wholly irrelevant and immaterial, and any attempt to superimpose those data upon the simple request for names only of materials, etc., will very likely lead to confusion and embarrassment and probably refusal. It is merely a qualitative list we are now after.

Now, why should we want such a list and why bother you with the labor of finding that list out? That is a question that I have been frequently asked. The answer to that is that the person does not live who can formulate a sure-enough definition of a product of or for chemical industry that will be intelligible to any one, and that would answer our purposes. Obviously our government cannot feasibly list separately each of the thousands upon thousands of different articles that enter our ports, and if it did so list them many of them would not be used. Just think of the sized volume that such a list would require! Since a verbal definition is out of question, the only refuge is in illustration. Now, your answer, like others, may very well be: "Tell the government we want all products of and for chemical industry listed item by item. Given them a copy of all chemical catalogues and tell them we want to know all about each item in those catalogues." Now the answer to that kind of an answer is that it is no answer at all. Self-evidently we as American commercial, industrial or manufacturing chemists cannot possibly be interested in every chemical listed in every chemical catalog, and moreover, we are interested and deeply so in many things that never are mentioned in any chemical catalog of any kind. For the same reasons we cannot refer the government to any one of the numerous Buyers' Guides. We cannot give the government a blanket list for the simple reason that there is no such list. England, France, Germany, Sweden, Canada, Switzerland, Italy and the United States, each and all have a different official notion of where products of and for chemical industry begin and end. Our own government's list is not adapted to our best service and I am sure that none of the other government's lists would be satisfactory, I have compiled such a composite list which has been published in at least four places.²

Your next question will probably be: "What will you do with that list after you get it?" To that the answer is that the Central Committee, of which I am a chairman, will, if the response is satisfactory, compile all of the submitted material into a composite list and ask the government to give us the quantities and values imported monthly, quarterly or annually as may appear best suited to our needs.

Then you will say: "Be sure and get a good classification; have it logical and scientific; the present classifications are so illogical and so unscientific." The answer to that is that we cannot, in reason, ask the government to alter its mode of collecting and classifying its information; all we have a right to do is to ask for a finer subdivision of the items reported. The reasons, among others, for this are:

The original sources of information are the consular invoices which are filed with the Treasury Department; for the purpose of determining the duty to be levied, the items of each invoice are classified or marked according to the relevant tariff law paragraphs and the duty rate stated.

In making up its returns the Treasury Department is primarily interested in the amount and value of dutiable goods entered under each of the paragraphs and the duty collected, and to a secondary or subordinate

*A paper read at a joint meeting of the New York Sections of the American Chemical Society, the American Electrochemical Society and the Society of Chemical Industry.
Journal of Indus. and Eng. Chem., 1915, p. 58; 1916, pp. 672 and 749. *Proc. Am. Inst. Chem. Eng.*, 1914, p. 43; *Metallurgical and Chemical Engineering*, 1916, p. 113. *Oil Paint and Drug Reporter*, July 31, 1916, p. 16. *Paint, Oil and Drug Review*, August 16, 1916, p. 11.

Metallurgical and Chemical Engineering, Aug. 1, 1916, p. 440; *Journal of Indus. and Eng. Chem.*, 1916, p. 749. *Oil Paint and Drug Reporter*, July 31, 1916, p. 16. *Paint, Oil and Drug Review*, Aug. 16, 1916.

extent as to the nature, quantity or values of the various items under each of those paragraphs. Then the Department of Commerce takes these invoices or the collated records of the Treasury Department and selects from them those items that it has reason to believe are specifically of interest to the public. Now, that is where we come in. We must tell the Department of Commerce with as great practical and practicable detail as we now can what specific items we as industrial chemists are really interested in. We cannot seriously be interested in every single item imported by any one or all of our chemical supply houses, and for that reason to have the government go to all that trouble would be in large part useless labor. The best we can do is to give the government the best sort of a line that we can on what we are really interested in.

At this point you will no doubt say: "Now, won't your committee get a lot of duplications in names and how am I to know what some other section reports?" The answer is: "Never mind about duplicates; you send in your stuff; duplicates are our troubles and we will handle that."

Still you may say: "Must I get a complete list of all we are interested in?" The answer is: "Not at all: just tell us what things are lacking in the various lists published in the *Journal of Industrial and Engineering Chemists* for August, 1916, or in *METALLURGICAL AND CHEMICAL ENGINEERING* for Aug. 1, 1916, or *Oil, Paint and Drug Reporter* for July 31, 1916, or *Paint, Oil and Drug Review* for Aug. 16, 1916, in which you are interested and we will do the rest. That is one way of doing it and as near as I can figure it, it is the shortest and easiest way, and further, it is the way I suggested in the article containing those lists. If you prefer to do it some other way—go to it, but get there!

"In other words, if our commerce reports were to list separately all the items given in all those various lists would your section of the country and its interests be taken care of? If not, what do you want added to those lists? All we want is the name of every addition you want."

Then you will probably ask: "What good do you expect from all this trouble you are asking us to go to?" The answer is: "Suppose antimony oxalate (which is not now reported in our reports) were shown to be imported in increasing quantity quarter by quarter, some domestic maker might make up his mind to go after that market and bag it for himself; tally one for the list! For we would be just that much nearer independence, and so on *ad lib*. Some day you might be the lucky man to make a ten-strike."

By this time, if you are like most of those to whom I talked during "Chemists' Week" in New York, you will begin to show signs of great personal interest and you may ask: "Will I have to dig through those big volumes every month to find out about these thousand-and-one-things?" The answer is: "Not at all, if the A. C. S. is alive and on the job. The government cannot reasonably be expected to get out a separate publication for us chemists; if it did it would have to do so for every other branch and there would be many overlapping. For example, suppose the leather industry to want such a separate list; many of its items are on our list, and so on down the line. The A. C. S. will have to separate out that information every time such a government report comes out and publish it in the *Journal of Industrial and Engineering Chemistry* and so that not everybody goes to sleep and gets the idea that that information is published merely to take up space, I should like to see a standing head something like the following:

"The information herein given was collected by our

government in the expectation that with its help our chemists will most intelligently and effectually work toward the self-containedness of the nation."

"This standing head would be a constant reminder to our members that they are expected to make intelligent and constructive use of that information, and also a reminder to our government that it too must keep awake and tell us of any newcomers so soon as they show up."

As I see it, the real lesson of the war to us as a people should be that our national well-being requires a diversified industry as well as an industry turning out large quantities. Up to twenty years ago or thereabouts Germany was largely engaged in diversifying her industry, and for the past twenty years or somewhat longer she has been engaged in "mass-production," so that for many years past Germany has had not only a highly diversified industry, but also one dealing in and producing large tonnages.

We have the large tonnage capacity and point of view, but we do not have the diversified industry point of view, and it is in order that we may acquire this latter in the shortest possible time that this present work has been undertaken.

With this fragmentary and sketchy introduction I will proceed to the more fundamental aspect of the case.

For upwards of thirty years the attitude of the country as expressed in three Republican and two Democratic tariffs and one Democratic partial tariff-revision, has been that our chemical industry in general and coal-tar dyes, in particular, shall not be protected and that any tariff laid on chemicals and dyes shall be non-protective and for revenue-yielding purposes only. The tariff efforts at protection were and are directed toward other industries.

Immediately upon the outbreak of the present war our press and the public severely scolded us chemists for not making coal-tar dyes; dyes seemed to be the limit of their information as to what chemists do. Many other and more important things which were in the same condition as dyes were overlooked, deliberately or otherwise, in this tirade and this fusillade of criticism. The reason was and is clear. The raw cotton market has been shot to pieces and fabricated cottons then on the market were made from high-priced cotton and buyers demanded sales at the then prevailing very low raw cotton prices; thereupon the manufacturers set up the dyestuff bogey to bolster up their demands for higher prices for fabricated cottons. Going behind the scenes, it is clear that this demand for dyestuff independence is, far more likely than not, artificial, and in the light of the experience of thirty years past, insincere and thoroughly non-dependable. Economic beliefs of the two political parties and the business policies of the nation more than thirty years old cannot be expected to be overturned so suddenly and such sudden alleged change cannot be sincere nor lasting, panic-time conversions and statements to the contrary notwithstanding. The chemists of the country will simply be living in a fool's paradise if they bank on it that the above view of our industry by the public has undergone or will soon undergo any lasting change.

In his speech of acceptance on Sept. 2, 1916, President Wilson said: "We have driven the tariff lobby from cover and obliged it to substitute solid argument for private influence." While this may be true as a general statement it does not at all apply to the inside history of the making of the dyestuff section of the Kitchin General Revenue bill. Leader Kitchin himself says that it was a compromise between the Hill bill rates or no added rates at all. The Kitchin rates are and were dictated solely by private influences privately exercised and

rest upon no "solid argument" nor public proceedings whatever; they are merely the result of "take what the dye-users offer you or you get nothing at all." A few only of the dye-users forced this situation; let no one be deceived, the big influences in the dye and chemical using field are not behind this movement at all. When the right time comes, and signs to that effect are already evident, those influences will have any rates above the Underwood tariff taken off, and taken off quickly at that, for they probably will not be permitted to raise the duties on their own finished products; then our domestic dye and chemical makers will be as badly off as ever, and our chemical industry instead of having been helped forward will have been given a "black eye" by the very politicians who professed to be its friends. The underlying reason for this on-the-surface solicitude for the welfare of our domestic chemical industry by both political parties is votes and is not dictated by any primary or real desire for a domestic chemical industry; our politicians are not yet educated up to that point. It has been variously estimated that 400,000 or 800,000 votes are to be found among the operatives of the dye-using industries; by some political legerdemain both political parties hope to convert this alleged dye-stuff solicitude into a solicitude for the welfare of those voters. The chemists of the country are worth hardly 10,000 votes to the politicians.

Further, it must be remembered that among domestic dye and chemical users the feeling is growing, "Well, we were more scared than hurt; we 'got by' this time; it's a long time to the next war; we should worry! Let others take care of themselves; we want cheap dye-stuffs and cheap chemicals and we do not care who makes them; dyes and chemicals are our raw materials and raw materials must be free."

On the theory of the "greatest immediate good to the greatest number," and this is perhaps for the present and the immediate future properly expressed by the number of influenceable or affected votes, it is reasonably certain that our country will not lastingly reverse itself in its fiscal and economic policy of the past generation. Products of chemical industry are not themselves and as such very largely sold to the "ultimate consumer," that is, the voter. They are largely used in making things that are made by and do reach the voters, and to those who make these things that thus reach the voter the products of chemical industry are raw materials, and the country long has been and still is fairly well united on the proposition that "raw materials must be free," and particularly where the making of those so-called "raw materials" in this country will not directly affect many—particularly voters.

Contrary to all the expectations raised by the recent discussions of the press, the country seems to have set adrift its new-born desire to insure to those industries that it has a domestic supply of such of their raw materials as are in reality highly manufactured products of other industries and has definitely decided to continue in this respect to be dependent upon foreign nations.

Based upon the classification and the figures of the census of 1909, and if we compare the average chemical plant with the average plant in all domestic industries, it appears that the average chemical plant, when so contrasted, costs 330 per cent of that general average, employs 144 per cent as many persons, of which the salaried employees are 264 per cent of the general average and the wage earners 134 per cent; the output value is 261 per cent of the general average, and its enhancement in value is 248 per cent. Therefore, as a unit, the average domestic chemical plant costs more, produces more, enhances more, employs more salaried

persons and more wage earners than the average industrial plant.

A dollar invested in our chemical industries is not so productive as in our industries as a whole; it spends less for wages, salaries and materials and produces less product-value and less enhancement-value.

Per \$100 of product, the general average and the average domestic chemical plant, respectively, expend \$16.58 and \$9.09 for wages, \$4.54 and \$5.65 for salaries, or \$21.12 and \$14.74 for services.

Per individual wage earner the annual output of product is \$3,125 for the general average and \$6,035 for the average domestic chemical plant.

Per individual salaried employee the annual output of product is \$26,157 for the general average and \$25,733 for the average domestic chemical plant.

Relatively, our chemical establishments are 0.79 per cent of all our industrial establishments, and the number of persons employed is 1.15 per cent of all persons employed in manufacture.

So that while an average chemical plant, as such, is of greater importance to the community than the average industrial plant, yet the capital so invested is not so productive as in the average industries. It is possible that sooner or later the American public will decide that our national well-being requires greater development along chemical lines since chemical products are raw materials for so many domestic industries, and will be prepared to take what steps may be necessary to accomplish that result, but until that time arrives we chemists must be prepared to make our own way, and on our own merits and independently of any economic help from politicians, for we must remember that whatever one set of politicians may give us another set of politicians can take away; such artificial help may merely be producing more of these undesirable ventures known as "war babies."

Obviously, therefore, we chemists cannot stop to quarrel with the facts, but we must simply make friends with the situation as it is. These are simply "the rules of the game." The country does not want to help us broadly, as is for the sixth time and conclusively proved by the happenings of the past two years, and yet the country, in a half-hearted way, wants and really should have a chemical industry—complete to be sure—but it will have to be content with what it can get in that direction. It is our duty to give the country the utmost that we can give it. We have done the best possible under the conditions of the past and present. In order to help our country more we must know with considerable particularity what our country buys from abroad. If our country wants us to help more than we have heretofore the country must tell us more than it has in the past. Chemists are not mind-readers nor clairvoyants. When the country says: "We import \$800,000 worth a year of fifty different chemicals," what good does that do it or do us? Could anything be more tantalizing to chemists? Why not tell us what those fifty things are and how much of each and at what price it reaches this country? Then we might be able to do something additional. Why should we be called upon to guess what these fifty items are and what their respective values and poundages are? The country has that information and why hide it?

If the chemists of the country were fully informed as to the values and amounts of imports into this country of products of and for chemical industry, we could then more intelligently and more surely work towards the self-containedness of the nation, and more completely utilize to the utmost all opportunities around us; if, then, added economic help in certain directions were clearly needed, and if by then President Wilson's

above statement has actually been realized with respect to our products and the country really wants our industry, it seems only reasonable to expect that such added help would then be forthcoming, promptly, permanently, willingly and intelligently.

Our first duty, then, is to tell the country how we suggest to have this added information imparted; then, if the country does really give us that, it will be our second duty to take hold of the opportunities thus disclosed and make them give up all they can be made to give up; we can then cross the next bridge when we come to it. In the meantime we have our hands full trying to get this request for more information into presentable and convincing form.

In making up this list of import items we must bear in mind that it should contain everything that a well rounded-out and self-contained chemical industry needs either in materials or apparatus or makes in the way of products, finished or intermediate, for its own use or for use in other and wholly non-related industries, and this is much more varied than any available list of such products; this is our real task—to make the list complete in every respect.

The function of such a complete list is three-fold: Firstly, it will inform government officials and the public of, and will visualize to both, the variegated and ramified activities and interests of chemical industry; secondly, by its illustrative character it will enable our government officials to "spot" a relevant newcomer in our field much more readily than otherwise; thirdly, it will tell us chemists ourselves a great deal more about our own business, our own opportunities and our obligations to other industries than any collection of text or handbooks ever could. It is rather a "tall order," but if we will not make up such a list why should we expect others to do our work for us? And who else should do it? It is our job and no one's else.

When considering the taking up of making things in this country that are up to then largely or wholly imported from abroad, we must bear in mind that, in general, increased domestic consumption follows domestic manufacture so that an imported item of \$10,000 per year may in a few years of domestic manufacture reach a consumption of three or four times that figure.

Finally, it must not be lost sight of that when we ask for greater subdivision of the items of imports in our commerce and similar reports we are not at all asking for a revision of the general classification. These reports can convey the same financial and other information as to the sources and amounts of revenue as heretofore; we do not ask to have this function of those reports curtailed nor hampered in the least; all we ask is that they be made to contain and to give more detailed information as to our items of purchases of products and for the chemical industry from abroad.

25 Broad Street,
New York City.

Salt Evaporation.—According to the United States Geological Survey, the United States produced 38,231,496 bbl. of salt in 1915. The larger part of our salt is produced by converting rock salt lying deep below the earth's surface into brine, artificially, then pumping said brine to the surface and evaporating it. Some idea of the values thus obtained may be best given by citing the statistics for the salt obtained in this manner in the states of Michigan, New York and Kansas. In Michigan, 6,708,261 bbl. of salt were obtained by means of evaporation, having a value of \$3,635,692, New York produced 3,443,464 bbl. valued at \$1,720,434, and Kansas 1,901,756 bbl. were marketed at \$696,060.

An Explanation of the Flotation Process*

By Arthur F. Taggart and Frederick E. Beach

Assistant Professors of Mining Engineering and of Physics respectively, Sheffield Scientific School, Yale University

The flotation process for the concentration of ores is a method by means of which one or more of the minerals in the ore (usually the valuable ones) are picked up by means of a liquid film and floated at the surface of a mass of fluid pulp. Here they are separated from the other minerals, which remain immersed in the body of the pulp. In general, the minerals which are floated are sulphides of metallic luster, but some other minerals of metallic luster such as graphite and some sulphides with adamantine luster, such as sphalerite and cinnabar, are amenable to treatment by the process.

The importance of flotation lies in the fact that it is primarily a "slimes process," by means of which the particles of valuable mineral, too fine for efficient gravity concentration, are saved with a high percentage of recovery. Recoveries in the mills treating low-grade copper sulphide ores have been advanced 10 to 20 per cent by the installation of the process, and similar increased savings have been accomplished by the same means in mills treating sulphide ores of zinc and lead.

When finely ground ore containing sulphides mixed with a siliceous or earthy gangue is brought gently onto the surface of a body of water, in a direction forming an acute angle with the surface of the water, a considerable portion of the sulphide constituent of the ore floats on the surface of the liquid, while the gangue sinks. This is the so-called film flotation, exemplified by the Wood and Macquisten processes.

When gas bubbles are introduced into a fluid pulp composed of finely ground ore and water, to which has been added (1) a small amount of certain oils, or (2) a small amount of certain acids or acid salts, or (3) a small amount of certain alkalies or alkaline salts, or (4) a small amount of a mixture of oil with acid or alkali, the sulphide particles in the ore are brought to the surface on the gas bubbles. These collect in a froth heavily laden with sulphide particles. The gangue particles are not brought up by the bubbles, but remain in the mass of the pulp. This is the so-called froth flotation. Its variations, acid-froth, agitation-froth, and pneumatic-froth processes are discussed in detail later.

The points to be explained in the operation of these processes are: (1) The flotation of solid particles in a liquid the specific gravity of which is less than that of the solid; (2) the preferential flotation of the sulphide portion of the mass; (3) the functions of the reagents used.

Theory

The theory here presented in explanation of the points listed in the preceding paragraph appeals to the following physical phenomena: Surface tension, adsorption, adhesion, and viscosity. The first three of these are closely related.

SURFACE TENSION

Every liquid surface in contact with a gas or its vapor behaves as if it were under tension. The value of this contractile force per unit width can be measured. Its value for water, 74 dynes per centimeter, is higher than for any other well-known liquid. (Liquid metals and fused salts are, of course, excepted.) This fictive tension is a convenient conception for many discussions and may be explained in terms of the intermolecular attractions of the substances forming the

*A paper read at the Arizona meeting of the American Institute of Mining Engineers, September, 1916.

boundary. Another and very useful way of considering the phenomenon is to regard each unit of surface as having associated with it an amount of potential energy which is numerically equal to the surface tension. This relation is established as follows:

If two wires, *A* and *B* (Fig. 1), are so placed as to slide on two fixed wires *C* and *D*, and if the wires *A*

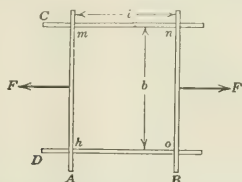


FIG. 1—POTENTIAL ENERGY OF SURFACE TENSION

and *B*, having been in contact, are separated a distance *l* against the pull of one of the surfaces only of a film, *mmoh*, by applying the force *F* the work per unit area will be

$$\frac{W}{A} = \frac{Fl}{lb} = \frac{F}{b} = T$$

which is obviously equal, numerically, to the force per unit width or the surface tension *T* of the one surface considered. Applying this conception of surface energy to different cases of contact, we can develop some statements of the relations of forces which are important in explaining many of the phenomena observed in flotation.

Consider first that two blocks of liquid, which have become rigid without any change in their other properties, are drawn together by the mutual action of their forces of molecular attraction until they perfectly unite over an area *A*. They would do an amount of work that we will represent by the letter *W*. Now consider that the same two bodies when brought near together, but not into contact, become liquid and unite over the area *A*. The work done is again *W*, but in this case it can be considered as due to the shrinkage of the surface by an amount 2*A*, whence $2AT = W = A(T + T)$, where *T* is the surface tension of the liquid. If two different liquids whose surface tensions are *T*₁ and *T*₂, respectively were brought together, the work due to the molecular attractions would be $(T_1 + T_2)A = W$, provided there was complete union, but if there is not complete union, there will be an interfacial tension *T*₁₂, and the energy equation becomes

$$(T_1 + T_2)A - T_{12}A = W$$

or

$$T_{12} = T_1 + T_2 - \frac{W}{A}$$

i.e., the interfacial tension *T*₁₂ is the excess of the sum of the two tensions over the work which is done by them in allowing a unit area of the two liquids to come into contact. If a liquid is brought into contact with a solid, the energy equation is $T_{1s} = T_1 - W_1$ (gas or vapor effects being excluded),

where *T*₁ = the surface tension of the liquid,

*W*₁ = the work done in bringing a unit area of the liquid and solid into contact,

and *T*_{1s} = the interfacial tension.

If, therefore, $W_1 = T_1$, the solid has the same attraction for the molecules of the liquid as the molecules of the liquid have for each other and there will be no interfacial tension. If $T_1 > W_1$, the interfacial tension *T*_{1s} will be positive; if $T_1 < W_1$, there will be negative inter-

facial tension or a surface pressure. In the latter case the liquid will tend to spread over the solid.

ANGLE OF CONTACT

When, as is the common case in the flotation process, there are three substances in contact, a system of forces as shown in Fig. 2 is brought into play. If *O* does not move indefinitely to the right or to the left, equilibrium will be attained when

$$T_{sl} = T_{gl} + T_{gl} \cos \theta$$

or

$$\cos \theta = \frac{T_{sl} - T_{gs}}{T_{gl}}$$

where *T*_{gs}, *T*_{gl}, and *T*_{sl} are the interfacial tensions or pressures at the gas-solid, gas-liquid, and solid-liquid contacts respectively. From this equation is deduced the important conclusion that as *T*_{sl} increases with respect to *T*_{gs}, the angle of contact θ becomes smaller (the gas and liquid being the same), or, in other words, the angle of contact is a measure of the tendency of one fluid to replace another on the surface of a solid. We have examined the angles of contact of the water-air, oil-air, and oil-water surfaces against a number of the common minerals. We have found, in general, that the air-water contact angle is less for gangue minerals than for sulphide minerals; that the air-oil contact angle is less for sulphides than for gangues and less for any given sulphide than the air-water contact angle, and that the water-oil contact with solids takes the form shown in Fig. 3.

We found further that the invariable effect of oiling

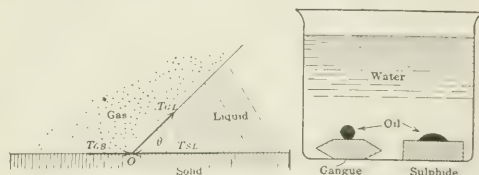


FIG. 2—CONTACT ANGLE

FIG. 3—WATER-OIL CONTACT WITH SOLIDS

a solid surface is to reduce the air-water contact angle. This latter phenomenon is undoubtedly aided by the reduction of the surface tension of the water due to contamination by the oil. This is further discussed later.

The conclusions forced by observation of the above phenomena are:

1. That water has a smaller tendency to displace air on the surface of sulphide minerals than on the surface of gangue minerals.

2. That the tendency of oil to displace air is greater at the surface of sulphide minerals than at the surface of gangue minerals.

3. That oil tends to displace water on the surface of sulphides and that water tends to displace oil at the surface of gangue minerals.

4. That water displaces air more readily on an oiled solid surface than on a clean surface of the same solid.

5. That these tendencies toward displacement are due to the interfacial tensions or pressures existing between the various substances, and that the resulting action of these interfacial forces is a manifestation of the tendency toward reduction of the total potential energy of the system. Wherever an increase in the solid-fluid interface will decrease the potential energy, such a change will occur.

These conclusions suggested the following confirmatory experiment.

A ring, 6.17 cm. outside diameter and specific gravity of 1.38, made of aluminium tubing, 0.63 cm. diameter, was cleaned and floated without trouble on the surface of pure water. The shape of the water surface at the air-water contact is shown in Fig. 4. The ring was then oiled slightly. The air-water contact angle was reduced, as shown in Fig. 5, to such an extent that it was impossible to float the ring. The same was true,

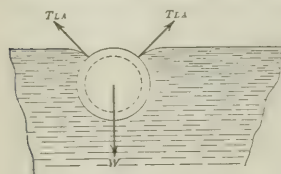


FIG. 4—SHAPE OF WATER SURFACE AT AIR-WATER CONTACT. THE ALUMINIUM TUBING UNOILED

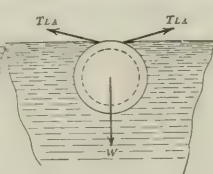


FIG. 5—CHANGE OF CONDITIONS DUE TO OILING THE ALUMINIUM TUBING

as might be expected, when a cylinder of aluminium replaced the ring. A similar cylinder of glass tubing exhibited such a small air-water contact angle that it could not be floated.

ADSORPTION

The surface layer between two physical phases is the seat of conditions of density and viscosity, also of apparent forces or energy manifestations, which are notably different from those in the bulk of either phase. On philosophical grounds it is impossible to consider that a real physical discontinuity occurs at the boundary between two media. In other words, there must be a very thin layer of transition in which there is a rapid but continuous change in the concentration of the components. This change in the concentration of a component at the interface is called adsorption, and may occur even between two phases which are ordinarily regarded as immiscible.

Adsorption at a gas-liquid interface may be demonstrated as follows: If a solid, which has been heated in a vacuum, is introduced into a measured volume of a gas over mercury in a calibrated tube, an amount of the gas will be adsorbed, as is shown by the change in pressure and volume compared to the space originally occupied.¹ These additional facts are established.

(a) The amount of the gas adsorbed at constant temperature increases with the pressure.

(b) It is different for different gases.

(c) It is different for different solids.

(d) It increases as the temperature decreases.

(e) There is an energy transformation which is indicated by the heat developed through adsorption, analogous to the Pouillet phenomena mentioned later.

(f) Chemical reactions are assisted by the adsorbed layer.

It follows that the gas layers must vary in density, falling off rapidly with increasing distance from the solid. Quincke assumes that the density of the gas next to the solid is equal to that of the solid, and concludes that the amount adsorbed will increase with the density of the solid. From these facts we conclude:

1. That gases and solids exhibit selective adhesion, and that, therefore, gas bubbles will attach themselves more persistently to some substances than to others.

2. That this selective adhesion is a manifestation of a definite amount of energy possessed by each unit area of a gas-solid contact, and that this potential energy is capable of variation.

3. That chemical reactions which diminish this potential energy are aided by adsorption.

Adsorption at a liquid-solid surface manifests itself in a vacuum, or where the vapor phase is negligible, by the way in which the liquid spreads or gathers itself together on the solid; in other words, in the way in which the liquid wets or adheres to the solid. It is further manifested by an evolution of heat, known as the Pouillet phenomenon. A calculation of the condensation necessary to evolve this amount of heat, in the case of water against glass, indicates that the specific gravity of water in the adsorbed layer is increased to about 2.1.²

Adsorption of the gas at a gas-liquid surface is indicated:

1. By the effect on the surface tension. The surface tension of a freshly formed mercury surface does not change in a vacuum, but falls off in the presence of different gases for about an hour. Certainly the density of a liquid cannot be constant at the boundary, but must go over continuously into that of the gas.

2. By the increase in the solvent power of the surface.³

3. In the case of contaminated liquids, by the concentration of one or more of the components of the liquid at the gas-liquid surface. Every unit area of such a boundary possesses a definite potential energy which always tends to a minimum. If, therefore, the surface tension of a solution depends upon the presence of any component, such a change of concentration of that component will occur as will reduce the potential energy, i.e., the interfacial tension. In other words, any component which reduces surface tension will be found in excess at the surface of a solution. For example, the surface tension of water is greater than that of alcohol. Experimentally, a drop of alcohol on a thin film of water rapidly reduces the surface tension of the water and the latter draws away from the alcohol. On the contrary, a drop of water on a thin film of alcohol spread over glass does not at once diffuse into the film but remains gathered in a heap. Such diffusion would increase the surface energy of the system, hence the water concentrates away from the gas-liquid surface. The greater viscosity of the surface of a solution above that of the bulk, or of that of a pure liquid, has long been recognized⁴ by its damping effect upon a swinging magnetic needle and may properly be ascribed to gas-liquid adsorption. Closely connected with this is the formation of elastic solid skins or very viscous layers at a free surface, as, for example, in the case of solutions of peptone and dyestuffs. A peculiarity of saponine solution is the rigidity of its surface while the interior remains more mobile.⁵ The surface of a freshly formed fairly concentrated solution of fuchsin is quite mobile, but in the course of a few hours it changes to a reflecting skin with solid properties. Similar results are obtained with methyl-violet and peptone. In the case of the latter substance the skin is highly elastic. There seems to be no doubt that true adsorption is present here. In the case of crystal-violet, which closely resembles methyl-violet in its properties, a solution of 1 g. to liter lowers the surface tension from 75 to 69.9 dynes per centimeter. Other causes for the production of a solid layer may, however, be present, for many of these substances in concentrated solutions stiffen into gelatines and since the concentration of the contaminant is great at the surface and the solubility has also a different value, the solid remains persistently. Either a chemically irreversible change or a transformation into a more difficultly soluble

¹ Lewis: *Phil. Mag.*, 20, p. 502, 1910.

² Pockels: *Nature*, Mar. 12, 1891, p. 439.

³ Daniels: *Physica*, p. 258, Fr., p. 76.

⁴ Boys: *Soap Bubbles*, p. 115.

⁵ Freundlich: *Kapillar Chemie*, p. 92.

phase at the surface is clearly the explanation of the persistence of the froth in albumen solution and the like. The properties of such surfaces apparently pass over imperceptibly into those of colloids.

Adsorption at the boundary between two liquids is evidenced by the effect on the interfacial tension just as in the gas-liquid solution surface, although the process is not one usually described as ordinary solution and one may also have to reckon with chemical reactions in the transition layer. With liquid-liquid surfaces, as in gas-liquid surface, the adsorption frequently gives rise to very viscous layers. The presence of such a viscous layer at an oil-water interface is easily shown by pouring any clear oil, kerosene,

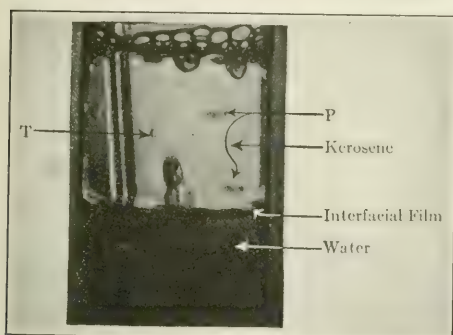


FIG. 6—EXPERIMENT VISCOUS FILM AT OIL-WATER INTERFACE

liquid vaseline, etc., onto water and then bubbling a gas through the water. Such an experiment is shown in Fig. 6. The interface has all the appearance of an elastic skin. Bubbles rising through the water and striking the under side of the interface stretch the film (see *H*, Fig. 7), and rising farther drag away a mass of water surrounded by this viscous layer. The system now appears as shown at *M* and rises to the oil-air surface on account of its lower specific gravity. Here the film, together with the excess water carried

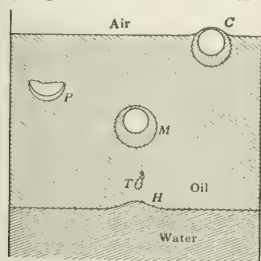


FIG. 7—DIAGRAMMATIC REPRESENTATION OF EXPERIMENT OF FIG. 6

up as shown at *C*, breaks away and falls back through the oil, not in spherical form, as would be the case were the water drop not surrounded by a viscous film, but in hemispherical form (see *P*, Figs. 6 and 7) often trailing behind it a film with ragged edges, as it broke from the bubble. The tadpole-shaped water drops, *T*, (Figs. 6 and 7) are further evidence of the high viscosity of the oil-water interfacial film.

VISCOSITY

A marked increase in the viscosity of interfacial films is produced by the presence of finely divided solid

matter. This increase is apparent in the experiment just described when finely powdered sulphide is thrown into the oil and allowed to settle to the interface, where it becomes entangled in the film. When gas bubbles are introduced, as before, the return water drops, coated with a film containing the solid particles, are much more irregular in shape than previously, and their coalescence after reaching the interface requires days or weeks.

An even more convincing proof of the increase in viscosity of an interfacial film is given by the following experiment. If a needle is floated at the center of a surface of pure water in a beaker 4 in. in diameter and a chip of wood is floated near the wall of the beaker, the needle, may be caused to revolve by means of a magnet without disturbing the chip. If the surface of the water is dusted over with fine ore, the whole surface together with the chip moves as though it were a rigid solid.

SUMMARY

The potential at a gas-sulphide contact is less than at a gas-gangue contact; hence gas bubbles will cling with greater persistence to sulphides than to gangues.

Oil replaces water at the surface of sulphide minerals.

Water replaces oil at the surface of gangue minerals.

Water replaces gas more readily at an oiled surface of a solid than at a clean surface.

The addition of any contaminant to water lowers the surface tension.

In any body of contaminated water there will be a concentration of the contaminant at the air-liquid surface.

Adsorption at a gas-liquid surface lowers the surface tension and increases the viscosity.

Adsorption at a liquid-liquid surface produces a film whose viscosity is higher than that of the bulk of either liquid.

The presence of finely divided solid matter in a film markedly increases the viscosity of the film.

Application to Commercial Flotation Processes

FILM FLOTATION

Pulp with or without oil or acid is fed gently, at an acute angle, onto the surface of a body of still water. The sulphide floats and the gangue sinks.

Possible cases:

Case 1.—Sulphide, gangue, water.

Case 2.—Sulphide, gangue, water, oil.

Case 3.—Sulphide, gangue, water, acid.

Case 4.—Sulphide, gangue, water, acid and oil.

Case 1. Sulphide, Gangue, Water.—The governing factor in the initial flotation of the sulphide and immersion of the gangue is the difference in the air-water contact angle with the sulphide and gangue surfaces respectively. If the difference is great, as in the case with galena and quartz, good separation is obtained. After a considerable amount of sulphide has been floated, if the surface flow is sufficiently impeded, the particles congregate into clumps by the well-known phenomenon of apparent attraction of floating particles,⁴ a scum is formed (whose viscosity and resistance to rupture are many times greater than that of the original water surface) and the floated particles are rendered more immune to immersion.

Case 2. Sulphide, Gangue, Water and Oil.—When oil is added in this process the phenomena are entirely different from the simple film flotation of Case 1. The

⁴Hastings and Beach: *General Physics*, p. 156

oil concentrates at the surface since such concentration reduces the surface energy of the system. This adsorption of the oil at the gas-water surfaces causes the formation of a viscous film. When the mixture of sulphide and gangue is introduced at the surface, the sulphide particles tend to migrate into this layer and the gangue particles migrate into the water, for a sulphide particle in contact with oil represents the condition of least potential energy which is possible for the sulphide particle to assume in the system of oil, sulphide, and water. Likewise the gangue particle surrounded wholly by water represents the condition of least potential energy for the gangue particle to assume in this system. In this case also, the formation of a scum of floated sulphide increases the stability of the float.

Case 3. Sulphide, Gangue, Water and Acid.—The effects of acid are: (a) to diminish the surface tension of the liquid, (b) to diminish the gas-liquid contact angle, and (c) to increase the viscosity of the gas-liquid surface. The diminutions of (a) and (b) are more marked with gangue minerals than with sulphides. The result is that cleaner concentrate may be expected than in either of the previous cases, but at the expense of richer tailing.

Case 4. Sulphide, Gangue, Water, Oil and Acid.—In this case a combination of results such as can be predicted from the preceding cases is obtained.

FROTH FLOTATION

In order to explain froth flotation it is necessary and sufficient that the gas of each bubble shall be inclosed by a film of contaminated water which shall possess the following characteristics:

1. Low surface tension.
2. High viscosity.
3. A variable concentration of the contaminant (regent).
4. A preferential adhesion of the bubble film to the sulphide mineral compared to that for the gangue minerals.

We will examine first the conditions required for the formation of a froth, or the continued existence of a thin film. Solutions which form froth are preëminently aqueous solutions and the properties of the liquid film are only secondarily determined by those of the gas.

The durability of a liquid film depends upon one or more of the following conditions:

1. A low surface tension which is locally variable so as to produce stable equilibrium.
2. High viscosity, which may pass over into
3. Chemical irreversibility and the production of solid skins.

Pure liquids do not foam; for example, water or alcohol. The reason is obvious. As the film is thinned out by stretching or by draining away of the liquid, the surface tension is reduced at some part below the general constant value. As soon as this begins the thicker and more powerful parts of the film drag away from the weakened parts which at once completes the rupture. These inequalities evidently would not be so marked or rapid in their operation if the surface tension were low. Increase of viscosity would also slow up the process. High viscosity and low surface tension do not occur in pure liquids. But the most important condition for durability is some means by which the equilibrium of the forces at any point in a film may be restored, when a variation of some of the forces occurs. In the case of a compound liquid or solution this is effected by the adsorption or change of concentration of one or more of the components in the film.

The surface tension of a solution is in general notably different from that of the pure solvent, and in case of water, whose surface tension is the greatest of any

liquid with which we are concerned, even a minute trace of impurity is sufficient to lessen its surface tension considerably.

Consider a film of water stretched on a vertical ring of wire. If the surface tension remained constant, as it does in the pure liquid when the thickness exceeds 0.000001 cm., the weight of the lower part would stretch down the upper part until it broke. If the water contains some component whose depletion at the weaker points increases the surface tension, equilibrium will be preserved. In the stretching of a film, and in the general running away of the liquid between the surfaces of the film, which reduces the total available amount of the contaminant, such decrease of the concentration and increase of surface tension does occur, and the film remains stable under a considerable variation of external conditions. The formation of bubbles as a result of this variation of surface tension alone is well exemplified by a simple aqueous solution of soap or of acetic acid. The running out of the liquid between the two surfaces is greatly retarded by the viscosity of the liquid, a property which may be largely influenced by the surface adsorption of one or more of the components.

When, then, gas bubbles are introduced into a liquid pulp where oil is present there is formed about each bubble a liquid film whose surface tension is less and whose viscosity is greater than that of the bulk of the liquid. Some of the solid particles of the pulp move into the film and are raised to the surface with the bubble. Since there is a concentration of oil in the film, and since the diminution in potential energy at an oil-sulphide contact is greater than at a water-sulphide contact, the contaminated layer replaces the water on the sulphide surface and the sulphide moves into the bubble film, while the gangue, on which water displaces oil, remains in greater measure in the body of the pulp. The bubbles, therefore, as they arrive at the surface, carry an excess of the sulphide minerals. Upon their arrival at the surface, the bubbles of the contaminated liquid persist, owing: (1) to their lower surface tension; (2) to their ability to adjust this tension to a state of stable equilibrium; and (3) to their greater viscosity which is markedly increased by the presence of the solid particles.

MECHANICAL-AGITATION FROTH PROCESS

Sulphide and gangue minerals are beaten up with water and oil, with or without acid, then allowed to flow into a box containing a considerable body of liquid nearly at rest. Bubbles coated with a preponderance of sulphide particles float to the surface and form a heavy, persistent froth. The gangue particles sink.

Two cases arise:

Case 1.—Sulphide, gangue, water and oil.

Case 2.—Sulphide, gangue, water, oil and acid.

Case 1. Sulphide, Gangue, Water and Oil.—When this pulp is beaten, air is mechanically entrapped in the form of bubbles. At the surface of every bubble in the mass there is a gas-contaminated-liquid contact which results in the adsorption at this surface of the contaminant, oil, and the production of a viscous film into which the sulphide particles, circulating in the mass, pass with a diminution in the potential energy of the system. The result is that in a very short time after the air bubble is entangled in the pulp, it is surrounded by a viscous sheath composed of an oil-water interfacial film in which are entangled a large number of sulphide particles. The presence of the solid particles greatly increases the viscosity of the bubble sheath. When the solid-coated bubble arrives in the settling box or spitzkasten it rises to the surface. Here

the bubble persists, or, bursting, transfers its load to other bubbles. This bubble persistence is due to a combination of several factors. The oils used have, in general, a slower evaporation rate than water. The tension of the bubble film is lower than the tension of a pure water bubble. The bubble has the power of adjusting itself to its tension, within limits, without bursting. The presence of the large amount of solid matter enormously increases the viscosity of the film.

Case 2. Sulphide, Gangue, Water, Oil and Acid.—The addition of acid has the twofold effect of further lowering the surface tension and increasing the adhesion ratio $\frac{\text{oil-solid}}{\text{water-solid}}$. The result is, in general,

cleaner concentrate with or without an increase in the sulphide content of the tailing.

Heating the pulp has, in some cases, a beneficial effect. Where this is true it is probably due to (a) decreased surface tension and consequent increased stability of the froth; (b) increased number of air bubbles formed by the air released from solution; (c) in the case of viscous oils, the greater area over which oil is spread and consequently the greater number of bubbles with a viscous oil-water interfacial film; (d) probable increase in solubility of the oil and consequent greater diffusion, resulting in more widespread adsorption in bubble films.

PNEUMATIC FROTH PROCESS

Sulphide and gangue minerals mixed with water and oil, with or without acid, are run into a tank with a porous bottom through which air is forced. The air bubbles rise to the surface with a coating of solid particles, preponderantly sulphide, while the gangue particles sink.

The principles involved in this method are the same as explained in the agitation-froth process. The only difference is in the method of introducing air. The result of this difference is that the bubbles in the pulp are much larger than in the agitation froth method; they arrive at the surface less heavily loaded in proportion to their area; the bubble films are, therefore, less viscous, and the froth less persistent.

POTTER-DELPRAT PROCESS

Sulphides and carbonates, with or without other gangue minerals, are treated with hot, dilute sulphuric acid. Bubbles of carbon dioxide and hydrogen sulphide are formed which rise to the surface with a sulphide coating and there form a froth. That part of the gangue not dissolved remains immersed. In this method as in the other froth methods, gas bubbles are formed which are surrounded by films of contaminated water, the contaminants in this case being sulphuric acid, lead sulphate, calcium sulphate and other salts formed by the action of the sulphuric acid. The films have a higher viscosity and a lower surface tension than is possessed by the bulk of the liquid. The sulphides move into the bubble films because the system composed of sulphide and this contaminated layer has a lower potential energy than the system composed of the pulp in the bulk of the liquid. The writers at first suspected that the selective action in this case might be due to preferential gas adsorption at the gas-sulphide contact, as opposed to a gas-gangue contact, but microscopic examination of mineral froths collected from the process showed that the solid particles in the froth were completely within the films and at no point in contact with gas. The persistence of the froth is due to the factors explained in connection with the other froth processes.

While the writers have made no appeal to electrostatic

forces or to colloidal phenomena in this discussion, they realize that the potential energy existing at the contact of dissimilar substances may well include electrical forces and that migration of the suspended solid particles under the influence of electrical charges, similar to the migration of colloids, may account for some of the selective action of the bubble films. But the agitation of the pulp in the mechanical- and pneumatic-froth processes and the generation of carbon dioxide gas on carbonate particles in intimate contact with sulphides in the acid-froth process, are sufficient, in their opinion, to bring every sulphide particles into contact with a bubble film. Once in contact, the preferential adhesion of the contaminated layer to a sulphide surface in the presence of water is sufficient to account for the persistent attachment of the sulphides to the bubble films, while on the other hand, the replacement of gas or oil by water on the surface of gangue particles explains the wetting and continued immersion of the latter.

The writers have a considerable bulk of experimental data on which many of the statements in the foregoing explanation are based. These, together with the data from other experiments which are projected, and photographs of many of the phenomena mentioned, they hope to present in a later paper.

New Haven, Conn.

THE CRACKING OF PARAFFIN BASE OILS

The Time Factor and the Temperature Factor Under Pressure

By Gustav Egloff, Thomas Twomey and Robert J. Moore

(Contribution from the Havemeyer Chemical Laboratory, Columbia University, 255.)

The present communication is one of a general series in the study of the products formed from the thermal and pressure decomposition of petroleum oils. It was undertaken with a view to ascertaining the type of oils which lend themselves most readily to the formation of aromatic hydrocarbons, gasoline and unsaturateds. The temperature, pressure and the time factor in the cracking of a number of oils have been communicated elsewhere.¹ In the present paper the production of the aromatic hydrocarbons benzene, toluene and xylene; the percentage yields of gasoline and unsaturateds have been determined from a paraffin base oil under constant pressure of 150 lbs. and varying temperatures and rates of oil flow.

As the object of this communication was to follow the percentage yields of the individual aromatic hydrocarbons, the unsaturateds and gasoline from a paraffin oil it was cracked at temperatures of 400, 450, 500, 550, 600, 650, 700 and 750 degrees C. and varying rates of oil flow of 6, 12, 16, 23, 30 and 36 gallons per hour. Twenty gallons of oil was used in each experiment at constant pressure of 150 lbs. per sq. in. Care was taken in controlling the temperature and rate of oil flow as slight variations in either factor would affect quite materially the percentage composition of the end products.

THE OIL USED FOR PRODUCTION

The oil used in the following experiments was what is called in oil technology a distillate or gas oil derived from a Pennsylvania crude petroleum. Its distillation analysis was as follows:—

¹Egloff, *MET. AND CHEM. ENG.*, 15, 125, 1916; Egloff, Twomey and Moore, *Jour. Ind. Eng. Chem.*, 8, Nov., 1916; Egloff and Twomey, *Jour. Phys. Chem.*, 20, 597, 1916; Rittman and co-workers, U. S. Bureau of Mines, Bulletin 114.

Temperature, Degree C	Per Cent by Volume	Specific Gravity, 15.5 Deg. C.
To 200	2.0	
200 to 250	7.3	0.792
250 to 300	57.0	0.818
300 to 350	28.0	0.827
Residue	5.5	
Loss	0.2	

In each experiment 20 gallons of oil was used, which was cleared of grit by a system of strainers in the oil feed line.

EXPERIMENTAL PROCEDURE

The experimental procedure consisted in passing 20 gallons of oil through a gas-heated, lap-welded steel tube of 8 inch diameter and 11.6 feet in length, set in a muffle furnace. The system was a closed one, maintained at 150 lbs. pressure, which was built up by means of a compressor using natural gas.

The temperature control between 400 degrees and 750 degrees C. was determined by means of a base-metal thermocouple which had been carefully calibrated against a platinum-iridium thermocouple and was found to be accurate within 5 degrees C plus or minus.

The rate of flow of the oil into the heated zone of the steel tube under constant temperature and pressure was varied from 6 to 36 gallons per hour. Several oil meters were tested out as to accuracy of registering the gallons of oil passing through per unit time until one was found accurate for the purpose. Care was taken in selecting the oil meter, due to the importance of the time factor in thermal and pressure decomposition of hydrocarbon oils.

The pressure of 150 lbs. per sq. inch was maintained constant by a control valve which allowed the gas in excess of the stipulated pressure to pass through a scrubbing system. This scrubbed gas was passed into the gas line to be utilized in heating the furnace.

An average sample of the gas analyzed is as follows:

ANALYSIS OF GAS		Per Cent by Volume
Unsaturated hydrocarbons		19.5
Benzene		0.9
Oxygen		0.4
Carbon monoxide		0.1
Carbon dioxide		0.2
Methane		61.0
Ethane		6.4
Hydrogen		11.1

The heating value in British thermal units of a number of gas analyses ranged between 1000 and 1400.

ANALYSES OF THE CRACKED OILS

The cracked oils recovered from the condensers were carefully filtered, due to the varying amounts of suspended carbon being present. The carbon if not removed would have yielded specific gravity values too high due to same adhering to the sides of the Westphal plummet. The analysis of the oil for benzene, toluene and xylenes was conducted according to a method already given.⁷ The gasoline was determined as the cuts to 150 degrees C. The unsaturateds were analyzed as the amount absorbed by concentrated sulphuric acid, the details of the method used have already been given.⁸

EXPERIMENTAL DATA

The data and discussion with tables are given under the following subdivisions:

A. The percentage and specific gravity of the oils recovered at various temperatures and rates of flow.

B. The distillation analysis of the recovered oils.

C. The percentage of unsaturateds in the distillation cuts of the recovered oils.

D. The percentages of benzene, toluene and xylenes in the recovered oils.

E. The percentages of benzene, toluene and xylenes on the basis of oil used for production.

F. The total percentages of aromatics (benzene, toluene and xylene) on basis of oil used.

G. The gasoline formation in the recovered oil and the specific gravity of the gasoline.

H. Gasoline on basis of oil used for production.

I. Percentage of olefins in the gasoline.

A. THE PERCENTAGE AND SPECIFIC GRAVITY OF OILS RECOVERED AT VARIOUS TEMPERATURES AND RATES OF FLOW

TABLE I		
RATE 6 GALLONS PER HOUR		
Temperature, Deg. C.	Per Cent Recovered	Specific Gravity
400	86.0	0.857
450	49.3	0.940
RATE 12 GALLONS PER HOUR		
450	78.0	0.887
500	75.0	0.901
550	45.2	0.972
600	33.9	0.981
650	17.5	0.978
RATE 16 GALLONS PER HOUR		
450	82.6	0.855
550	58.0	0.905
600	46.5	0.945
650	29.7	0.986
RATE 23 GALLONS PER HOUR		
450	93.6	0.852
500	81.3	0.864
550	61.8	0.865
600	51.8	0.890
650	44.8	0.949
700	33.3	0.989
RATE 30 GALLONS PER HOUR		
500	90.0	0.862
550	69.5	0.872
600	63.0	0.882
650	53.3	0.895
700	46.0	0.931
750	38.4	0.952
RATE 36 GALLONS PER HOUR		
500	91.0	0.851
550	78.0	0.856
600	71.2	0.886
650	55.5	0.914
750	42.3	0.950

TABLE II—THE PERCENTS OF OILS RECOVERED AT VARYING TEMPERATURES AND RATES OF OIL FLOW

Rate, gals. per hr.	6	12	16	23	30	36
Temperature, Deg. C	PERCENTS BY VOLUME					
400	86.0					
450	49.3	78.0	82.6	93.6		
500		75.0	81.3	86.4	90.0	91.0
550		45.2	58.0	61.8	69.5	78.0
600		33.9	46.5	51.8	63.0	71.2
650		17.5	29.7	44.8	53.3	
700				33.3	46.0	55.5
750					38.4	42.3

TABLE III—THE SPECIFIC GRAVITY OF THE RECOVERED OILS AT VARYING TEMPERATURES AND RATES OF OIL FLOW

Rate, gals. per hr.	6	12	16	23	30	36
Temperature, Deg. C	SPECIFIC GRAVITIES					
400	0.857					
450	0.940	0.887	0.855	0.852		
500		0.901	0.864	0.864	0.862	0.851
550		0.972	0.905	0.865	0.872	0.856
600		0.981	0.945	0.890	0.882	0.886
650		0.978	0.966	0.940	0.895	0.881
700				0.980	0.981	0.914
750					0.952	0.950

⁷ FILLARD, TWISSON AND BRIDGF, MET. AND CHEM. ENG., 13, 682, 1915.

⁸ BRIDGF AND TWISSON, MET. AND CHEM. ENG., 14, 247, 1916.

The rate of oil flow evinced the same tendencies as has been shown with other oils, namely, that with increase of rate of flow, i. e., with lessening the time of reaction, there was an increase in the amount of oil recovered. This is naturally to be expected since it follows well known physical laws. The oil, therefore, run at 36 gallons per hour showed for the temperature of 500 deg. C. a recovery of 91.0 per cent of the original, while the oil run at one-sixth that speed showed a recovery of only 49.3 per cent even at a lower cracking temperature.

A great difference in the chemical changes undergone would be expected from varying merely this one factor, and emphasis is again given to the importance of factor control in gas cracking where, besides this important time factor, we have the variables of temperature and pressure to consider.

Another factor of importance is that of concentration in cases where partial pressures of different gases admixed are taken into consideration. With these variables and their importance in mind, then, it can readily be seen what a vast field of experimentation is open, involving their use before the value of any oil can be definitely determined. There, again, the starting oil furnishes in a sense another factor for experimental consideration.

Since decrease in the time factor (increase in rate of flow) showed marked differences in recovered oil, a maximum and minimum soon showed themselves, above which and below which it was not practical to work. For instance, the higher temperature runs at the lowest rate of flow were discontinued owing to small percentage of oil recovered. Here sufficient time had been given the reaction to go largely to carbon and gas, and although good yields of products might be obtained from the recovered oil, yet calculated upon the basis of oil used these percentages would be small.

Further, the runs below 500 degrees C. at the two highest speeds were also discontinued, but owing to the slight amount of change in the recovered oil, although the amount recovered was over 90 per cent of the starting oil.

The temperature factor exercised the importance usually manifested in hydrocarbon work. With increase in cracking temperature there resulted a marked decrease in the amount of oil recovered, meaning that greater decomposition had taken place. Here, again, as in fixing the rate of flow, operating conditions had to be confined between limits giving on the one hand minimum change with high percentage recovery and on the other maximum change with low percentage recovery. As would be expected the temperature factor was much more important at the lower rates of oil flow. From Table II. it can be seen that a temperature change of 50 deg. C. at 6 gallons per hour exercised as much control over the percentage recovered as a change of about 200 deg. C. at 36 gallons per hour.

Table III. shows an increase in the specific gravity of the recovered oil with increase in cracking temperature; and also for each temperature used a decrease in specific gravity with increase in rate of oil flow. This again checks other percentage recovery figures in showing less chemical change at increased speed. With further increase of speed the oil recovered would approach 100 per cent and its specific gravity that of the starting oil.

The distillation analyses of the recovered oils are given in Table IV. and their specific gravities in Table V. From comparisons of these two tables information may be drawn as to the relative amounts of aromatics and paraffin in any one cut. For instance, the cut to 95 degrees C. of the 650 deg. run at 12 gallons per hour shows a specific gravity of 0.876, meaning almost

B. THE DISTILLATION ANALYSES OF THE RECOVERED OILS
TABLE IV

RATE 6 GALLONS PER HOUR			
Temperature, Deg. C.	400	450	
PERCENTAGE BY VOLUME			
To 95.....	7.9	9.9	
95 to 120.....	4.9	8.2	
120 to 150.....	5.0	7.4	
150 to 170.....	5.5	5.6	
170 to 200.....	7.8	9.1	
230 to 270.....	28.3	19.3	
270 to pitch.....	25.2	16.3	
Pitch.....	21.4	25.1	

RATE 12 GALLONS PER HOUR					
Temperature, Deg. C.	450	500	550	600	650
PERCENTAGE BY VOLUME					
To 95.....	7.7	8.7	13.3	18.9	26.6
95 to 120.....	4.8	6.6	9.3	10.4	12.3
120 to 150.....	4.9	5.7	6.1	5.9	3.3
150 to 170.....	5.4	5.5	4.5	2.1	1.1
170 to 230.....	9.3	8.6	11.9	7.6	10.1
230 to 270.....	27.6	20.6	11.7	10.5	15.9
270 to pitch.....	28.6	24.4	13.3	9.4	16.3
Pitch.....	11.7	19.9	29.6	36.2	25.8

RATE 16 GALLONS PER HOUR					
Temperature, Deg. C.	450	500	550	600	650
PERCENTAGE BY VOLUME					
To 95.....	8.6	12.1	16.0	24.0	
95 to 120.....	7.2	9.4	10.7	14.1	
120 to 150.....	6.2	6.6	8.1	5.9	
150 to 170.....	4.6	6.3	5.5	0.7	
170 to 230.....	7.4	8.9	8.4	11.0	
230 to 270.....	25.6	18.9	15.4	13.1	
270 to pitch.....	20.7	15.3	11.2	8.9	
Pitch.....	19.7	21.5	24.7	22.3	

RATE 23 GALLONS PER HOUR							
Temperature, Deg. C.	450	500	550	600	650	700	750
PERCENTAGE BY VOLUME							
To 95.....	3.4	8.1	11.2	12.1	14.0	21.5	
95 to 120.....	2.6	4.7	5.7	7.4	10.8	10.4	
120 to 150.....	3.5	5.4	5.5	4.7	5.7	4.6	
150 to 170.....	3.6	5.5	6.2	5.8	4.8	1.2	
170 to 230.....	10.6	16.4	14.3	16.4	7.8	9.5	
230 to 270.....	31.0	29.0	17.9	18.3	24.3	14.0	
270 to pitch.....	37.0	17.5	22.2	17.3	8.3	12.1	
Pitch.....	8.3	13.4	17.0	18.0	24.3	26.7	

RATE 30 GALLONS PER HOUR							
Temperature, Deg. C.	450	500	550	600	650	700	750
PERCENTAGE BY VOLUME							
To 95.....	8.4	10.0	11.2	12.1	15.4	18.9	
95 to 120.....	6.8	8.0	8.2	8.0	7.4	12.7	
120 to 150.....	6.6	6.4	6.5	6.0	5.7	7	
150 to 170.....	6.6	5.7	5.1	6.8	5.7	5.0	
170 to 230.....	8.7	11.3	9.8	10.5	15.5	11.1	
230 to 270.....	23.0	25.6	19.3	18.5	18.5	16.2	
270 to pitch.....	23.5	16.8	17.4	16.1	9.6	5.8	
Pitch.....	16.4	16.2	22.5	22.0	22.2	22.8	

RATE 36 GALLONS PER HOUR							
Temperature, Deg. C.	450	500	550	600	650	700	750
PERCENTAGE BY VOLUME							
To 95.....	5.3	7.4	11.2	14.8	16.1		
95 to 120.....	4.0	4.9	7.1	8.4	11.7		
120 to 150.....	4.0	4.0	6.2	7.3	7.7		
150 to 170.....	3.7	6.0	6.3	7.5	5.3		
170 to 230.....	7.3	10.7	9.8	9.0	15.8		
230 to 270.....	35.2	29.4	24.2	21.6	13.9		
270 to pitch.....	23.8	19.9	16.1	12.8	5.9		
Pitch.....	15.8	17.7	19.1	18.6	23.6		

TABLE V—THE SPECIFIC GRAVITIES OF THE DISTILLATION CUTS OF THE RECOVERED OILS

RATE 6 GALLONS PER HOUR		
Temperature, Deg. C.	400 Deg. C. Run	450 Deg. C. Run
To 95.....	0.718	0.787
95 to 120.....	0.787	0.846
120 to 150.....	0.801	0.865
150 to 170.....	0.824	0.873
170 to 230.....	0.834	0.905
230 to 270.....	0.867	0.943
270 to pitch.....	0.879	0.982

RATE 12 GALLONS PER HOUR

Temperature, Deg. C.	40	500	550	600	650
To 95	0.718	0.734	0.813	0.861	0.876
95 to 120	0.784	0.798	0.860	0.862	0.872
120 to 150	0.800	0.813	0.862	0.862	0.871
150 to 170	0.820	0.833	0.872	0.872	0.876
170 to 230	0.853	0.859	0.951	.....	.....
230 to 270	0.875	0.881	0.972	.....	.....
270 to pitch	0.884	0.896	1.002	.....	.....

RATE 16 GALLONS PER HOUR

Temperature, Deg. C.	450	550	600	650
To 95	0.728	0.756	0.809	0.868
95 to 120	0.798	0.823	0.852	0.867
120 to 150	0.810	0.837	0.860	0.869
150 to 170	0.820	0.847	0.870	0.879
170 to 230	0.867	0.898	0.938	.....
230 to 270	0.886	0.926	0.971	.....
270 to pitch	0.904	0.957	1.003	.....

RATE 23 GALLONS PER HOUR

Temperature, Deg. C.	450	500	550	600	650	700
To 95	0.714	0.726	0.728	0.743	0.814	0.866
95 to 120	0.772	0.788	0.793	0.812	0.848	0.865
120 to 150	0.790	0.802	0.806	0.824	0.852	0.868
150 to 170	0.800	0.812	0.816	0.834	0.862	0.878
170 to 230	0.831	0.849	0.866	0.881	0.923	.....
230 to 270	0.845	0.874	0.885	0.906	0.954	.....
270 to pitch	0.856	0.881	0.896	0.935	0.995	.....

RATE 30 GALLONS PER HOUR

Temperature, Deg. C.	500	550	600	650	700	750
To 95	0.717	0.732	0.751	0.756	0.842	0.845
95 to 120	0.774	0.797	0.810	0.815	0.858	0.865
120 to 150	0.778	0.813	0.820	0.823	0.860	0.866
150 to 170	0.788	0.823	0.830	0.835	0.870	0.870
170 to 230	0.843	0.861	0.872	0.891	0.941	.....
230 to 270	0.855	0.885	0.892	0.905	0.978	.....
270 to pitch	0.871	0.901	0.913	0.930	1.016	.....

RATE 36 GALLONS PER HOUR

Temperature, Deg. C.	500	550	600	700	750
To 95	0.716	0.718	0.745	0.782	0.851
95 to 120	0.776	0.781	0.812	0.835	0.858
120 to 150	0.796	0.797	0.821	0.841	0.858
150 to 170	0.806	0.808	0.831	0.851	0.868
170 to 230	0.826	0.848	0.875	0.902	.....
230 to 270	0.855	0.862	0.897	0.930	.....
270 to pitch	0.865	0.872	0.907	0.962	.....

C THE PER CENT OF UNSATURATEDS IN THE DISTILLATION CUTS OF THE RECOVERED OILS

TABLE VI

RATE 6 GALLONS PER HOUR

Temperature, Deg. C.	400	450
To 95	32	28
95 to 120	28	17
120 to 150	25	16
150 to 170	31	35
170 to 230	14	16
230 to 270	12	17
270 to pitch	12	21

PER CENT BY VOLUME

RATE 12 GALLONS PER HOUR

Temperature, Deg. C.	450	500	550	600	650
To 95	40	52	23	11	6
95 to 120	22	20	10	9	4
120 to 150	17	19	12	12	11
150 to 170	23	34	13	..	..
170 to 230	12	13	18	10	16
230 to 270	13	14	27	21	6

RATE 16 GALLONS PER HOUR

Temperature, Deg. C.	450	500	550	600	650	700
To 95	39	..	26	25	9	8
95 to 120	20	..	19	9	8	8
120 to 150	17	..	19	15	10	..
150 to 170	23	..	20	..	..	..
170 to 230	16	..	17	13	..	..
230 to 270	16	..	22	16	14	..
270 to pitch	14	..	30	21	20	..

RATE 23 GALLONS PER HOUR

Temperature, Deg. C.	450	500	550	600	650	700
To 95	37	44	46	43	23	9
95 to 120	20	20	23	18	15	7
120 to 150	22	19	23	23	16	26
150 to 170	23	32	61	33	35	94
170 to 230	59	15	16	18	14	40
230 to 270	9	11	13	16	18	36
270 to pitch	8	11	15	20	25	20

PER CENT BY VOLUME

RATE 30 GALLONS PER HOUR

Temperature, Deg. C.	500	550	600	650	700	750
To 95	47	42	36	32	12	12
95 to 120	24	19	19	22	9	11
120 to 150	25	21	18	16	13	11
150 to 170	27	28	45	31	95	34
170 to 230	14	18	15	15	15	13
230 to 270	12	15	14	11	15	12
270 to pitch	11	17	18	17	27	22

RATE 36 GALLONS PER HOUR

Temperature, Deg. C.	44	47	35	..	29	14
To 95	44	47	35	..	29	14
95 to 120	22	27	22	..	17	8
120 to 150	23	17	27	..	20	15
150 to 170	27	26	38	..	40	23
170 to 230	12	12	16	..	17	10
230 to 270	10	10	15	..	15	18
270 to pitch	9	10	15	..	23	26

cuts varied, dependent upon the cut, from a minimum of 4 per cent to a maximum of 95 per cent. The greatest average percentage formation of olefins occurred in the benzene cut to 95 deg. C., which would indicate a relatively high percentage formation of the amylenes, hexylenes and heptylenes. Low temperature and high rates of oil flow are conducive to unsaturated hydrocarbon formation. With increase of the cracking temperature, the percentage formation of unsaturates falls off toward a minimum. Likewise with increase of the time factor, the unsaturates approach a minimum.

The formation of the aromatic hydrocarbons benzene, toluene, and xylene, due to thermal and time factor-effects, from a paraffin base oil is clearly brought out by this table, in the recovered oil.

pure benzene. The volume of this cut is 26.6 per cent of the entire oil recovered from the run. Using the same 12 gallons per hour table and tracing the formation across to the columns of lower temperature runs we find that the specific gravity falls off markedly, indicating low boiling paraffin formation, the volume of the cut decreasing at the same time to 7.7 per cent.

Criss-cross comparisons of this nature make these tables extremely important in following the trend of the reactions. For instance, using again the columns just referred to, we find that while the cut to 95 deg. C. has increased in volume to 26.6 per cent with increase in temperature of cracking, the cut 150 deg. to 170 deg. C. has decreased to 1.1 per cent at the same time. We may, therefore, infer that the benzene has formed at the expense of the higher boiling point hydrocarbons.

A chain of reasoning can then be followed through the entire distillation analysis throwing much light upon just what has occurred and information is obtained as to controlling the factors of temperature and time for producing better yields of whatever hydrocarbons are desired.

The percentage of unsaturates in the distillation

D. THE PER CENT OF BENZENE, TOLUENE AND XYLENE IN THE RECOVERED OILS

TABLE VII

Rate, gals. per hr.	6	12	16	23	30	36
Temperature, Deg. C	PER CENT BENZENE BY VOLUME					
400	0.0					
450	4.8	0.0	0.4	0.0		
500		1.3		0.3	0.0	0.0
550		7.9	2.1	0.4	0.8	0.0
600		12.2	8.9	1.7	1.2	1.7
650		26.3	22.3	8.3	2.3	
700				18.7	11.8	5.8
750					14.8	13.7
	PER CENT TOLUENE BY VOLUME					
400	1.8					
450	6.3					
500		1.8	3.5	0.6		
550		3.2		2.0	2.1	1.0
550		8.6	6.4	2.5	3.7	1.8
600		7.9	9.4	4.4	3.2	4.2
650		12.3	13.8	9.2	4.5	
700				9.5	6.7	6.3
750					11.5	10.6
	PER CENT XYLENE BY VOLUME					
400	1.9					
450	6.1					
500		1.7	2.8	0.9		
550		2.7		2.0	1.1	1.6
550		5.7	4.6	2.2	3.1	1.4
600		3.3	7.4	2.6	2.9	3.4
650		3.3	5.9	4.9	3.2	
700				4.5	5.1	5.4
750					6.5	5.7

The formation of benzene from a paraffin base oil is a function of temperature, pressure, time factor and catalysis. In the particular oil used in this series of experiments the critical temperature of benzene formation occurred between 400 deg. C. and 450 deg. C. and rate of oil flow of 6 gal. per hour or 1 gal. of oil vaporized in the cracking area, 10 minutes, at 150 lb. pressure.

This formation holds only for the critical temperature when the rate is 6 gal. per hour. With change of rate of oil flow a change necessarily must be made in the temperature for benzene formation. As the rate of oil flow is increased the temperature of benzene formation increases from 450 deg. C. at 6 gal. per hour to 600 deg. C. and 36 gal. per hour.

The effect of the time factor is emphasized particularly in the benzene formation figures. The tables show that benzene is formed in appreciable quantities at 450 deg. C. at a rate of 6 gal. per hour. But, if the rate is increased to 36 gal. per hour, to form benzene the temperature must be raised 150 deg. higher than for the slower rate.

When the rate of oil flow is held constant and the temperature is increased the percent of benzene in the recovered oil increases to a maximum in each case. The maximum percentage 26.3 of benzene occurred at 12 gal. per hour and 650 deg. C. in the recovered oil. For corresponding rate of oil flow toluene and xylene form at lower temperatures than does benzene, without exception.

This phenomenon has added experimental evidence as to the formation of the higher methyl derivatives of benzene occurring first when paraffin base oils are subjected to cracking. This is in accord with experimental work upon the pure aromatic hydrocarbons benzene, toluene and xylenes.⁴ Subjecting the xylenes to cracking conditions the reaction products resulting gave toluene, benzene, naphthalene and anthracene, carbon and gas. Toluene gave similar products with some formation of higher methyl derivatives. Benzene formed methyl derivatives to only a very slight extent going mainly to diphenyl and polycyclic hydrocarbons.

The maximum of 7.4 per cent formation of xylene oc-

curred at 600 deg. C. and 16 gal. per hour and for toluene 13.8 per cent under the same conditions. In general increase of temperature increased the percentage formation of toluene, while for xylene the percentage increased to a maximum and then decreased with increase of temperature. At constant temperatures increase of the time factor gave a maximum of toluene and xylene and then a decrease.

E. THE PERCENTAGES OF BENZENE, TOLUENE AND XYLENE ON THE BASIS OF OIL USED FOR PRODUCTION

TABLE VIII

Rate, gals. per hr	6	12	16	23	30	36
Temperature, Deg. C	PER CENT BENZENE BY VOLUME					
400	0.0					
450	1.4					
500		0.0	0.3	0.0		
550		3.6	1.6	0.3	0.6	0.0
600		4.2	4.1	0.9	0.8	1.2
650		4.6	6.6	3.7	1.2	
700				6.2	5.4	3.2
750					5.7	5.8
	PER CENT TOLUENE BY VOLUME					
400	1.5					
450	3.1					
500		1.4	2.9	0.5		
550		2.4		1.6	1.8	0.9
550		3.9	3.7	1.5	2.5	1.4
600		2.7	4.4	2.3	2.0	3.0
650		2.2	4.1	4.1	2.4	
700				3.2	3.1	3.5
750					4.4	4.5
	PER CENT XYLENE BY VOLUME					
400	1.6					
450	3.2					
500		1.3	2.3	0.8		
550		2.0		1.6	1.0	1.4
550		2.6	2.6	1.4	2.2	1.1
600		1.1	3.4	1.3	1.8	2.4
650		0.6	1.8	2.4	1.7	
700				1.5	2.3	3.0
750					2.5	2.4

The percentage yield of benzene on the basis of oil used for production at constant rate of oil flow increased with increase of temperature. The maximum yield of 6.6 per cent of benzene was found to occur at 650 deg. C. and 16 gal. per hour. In general the formation of benzene decreased with increase of the rate of oil flow at constant temperature. Within the temperature limits of the experiments 400 deg. to 750 deg. C., benzene increased with increase of temperature at constant rate.

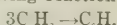
The formation of toluene and xylene reached a maximum with increase of temperature at constant rate and then decreased. The maximum percentage yield of toluene of 4.5 was obtained at 750 deg. C. and 36 gal. per hour and for xylene 3.4 per cent at 600 deg. C. and 16 gal. per hour.

One of the significant points in the above data lies in the fact that benzene, toluene and xylene form, at the low temperatures of 400 deg. and 450 deg. C., from a paraffin base oil having a boiling point range lying between 200 deg. and 350 deg. C. Their formation cannot be ascribed entirely to the possible presence in the starting oil of the phenyl radical. The low specific gravity and sulphonation of the distillation cuts of the starting oils indicate practically pure paraffin hydrocarbons, no aromatic, and possibly small traces of naphthene present. This brings the question of the mechanism of the reaction in forming benzene, toluene and xylene from acetylene, crotonylene, ethylene, propylene, butylene or amylene, which may have been formed at these low temperatures from the paraffin oil.

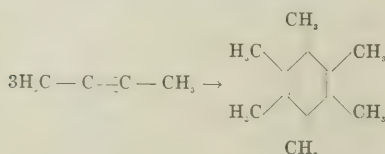
It is questionable as to whether acetylene or crotonylene form at 400 deg. or 450 deg. C. from a paraffin base oil of high boiling point range. These two hydrocarbons have been isolated from high temperature de-

⁴Rittman, Egloff and Byron, *Jour. Ind. Eng. Chem.*, 7, 1019, 1915.

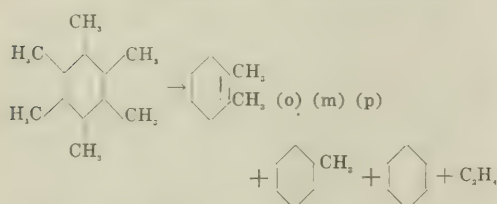
composition of paraffin oils. No one as far as we know has isolated acetylene or crotonylene from low temperature decomposition of paraffin oils. Experimentally it has been determined that acetylene forms benzene according to the following reaction



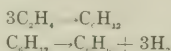
taking crotonylene therefore as one of the products of the reaction its course would be as follows:⁴



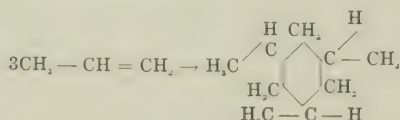
which would form hexamethyl benzene. This in turn decomposing into the lower methyl derivatives of benzene and forming ethylene which is usually formed in large amounts in hydrocarbon decomposition work.



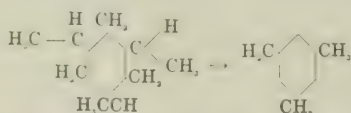
The ethylene formed polymerizing to form hexahydrobenzene—which decomposes at low temperature to form benzene.⁶



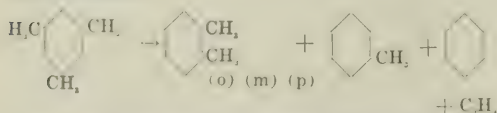
Decomposing three molecules of pyropylylene the following reaction may take place:



forming the saturated naphthene hydrocarbon hexahydro-mesitylene. This compound could readily split off hydrogen forming mesitylene.



Mesitylene can in turn decompose to form xylene, toluene and benzene.



The total percentage of benzene, toluene and xylene upon the basis of oil used increased with increase of temperature at constant rate of oil flow. The maximum formation of 12.7 per cent occurred at 750 deg. C. and 36 gal. per hour. At constant temperature in general the percentage formation of total aromatics decreased

⁴Acetylene with sulphuric acid is polymerized forming hexamethyl benzene.

⁶Solomon and Soderberg, *Am. Chem. Phys.*, 8, 4, 158, 1905; Zelinsky, *Berichte*, 44, 3121, 1911.

F. THE TOTAL PER CENT AROMATICS (BENZENE, TOLUENE AND XYLENE) ON BASIS OIL USED

Rate, gals. per hr.	TABLE IX					
	6	12	16	23	30	36
Temperature, Deg. C.	PER CENT BY VOLUME					
400	3.1	...	...	...	...	...
450	7.7	2.7	5.5	1.3	...	...
500	...	5.4	...	3.4	2.8	2.3
550	...	10.1	7.9	3.2	5.3	2.3
600	...	8.0	11.9	4.5	4.6	6.6
650	...	7.4	12.5	10.2	5.3	...
700	...	...	...	10.9	10.8	9.7
750	...	...	...	...	12.6	12.7

with increase of the rate of oil flow. It is to be expected that with increase of temperature the formation of cyclic hydrocarbons of the benzene series would increase due to their greater stability in comparison with the long chained paraffin hydrocarbons of the starting oil, at the increased temperatures.

The formation of gasoline in the recovered oil ranged from a minimum of 14.2 to a maximum of 44 per cent. The specific gravity of the gasoline cut to 150 deg. C.

G. THE GASOLINE FORMATION IN THE RECOVERED OILS AND THE GASOLINE SPECIFIC GRAVITIES. (TABLES X, XI AND XII)

TABLE X		
RATE 6 GALLONS PER HOUR		
Temperature, Deg. C.	Per Cent Gasoline	Specific Gravity
400	17.8	0.756
450	24.6	0.812
RATE 12 GALLONS PER HOUR		
450	17.4	0.760
500	21.0	0.772
550	28.7	0.831
600	34.2	0.861
650	42.2	0.874
RATE 16 GALLONS PER HOUR		
450	22.0	0.763
500	28.1	0.797
600	34.8	0.820
650	44.0	0.867
RATE 23 GALLONS PER HOUR		
450	9.5	0.759
500	18.2	0.752
550	22.4	0.766
600	24.2	0.781
650	30.5	0.835
700	36.5	0.806
RATE 30 GALLONS PER HOUR		
500	21.8	0.753
550	24.4	0.774
600	25.9	0.787
650	26.1	0.789
700	28.5	0.842
750	39.1	0.851
RATE 36 GALLONS PER HOUR		
500	14.2	0.753
550	16.3	0.758
600	24.5	0.776
700	30.5	0.804
750	35.5	0.854

TABLE XI—PERCENTAGE OF GASOLINE IN RECOVERED OILS

Rates of flow,	6	12	16	23	30	36
Temperature, Deg. C. of Run						
400	17.8	...	...	...	...	...
450	24.6	17.4	22.0	9.5	...	...
500	...	21.0	...	18.2	21.8	14.2
550	...	28.7	28.1	22.4	24.4	16.3
600	...	34.2	34.8	24.2	25.9	24.5
650	...	42.2	44.0	30.5	30.5	26.1
700	...	...	...	36.5	28.5	30.5
750	...	...	...	...	39.1	35.5

TABLE XII—SPECIFIC GRAVITIES OF THE GASOLINE CUTS

Rates of flow,	6	12	16	23	30	36
Temperature, Deg. C. of Run						
400	0.756					
450	0.812	0.760	0.763	0.759		
500		0.772		0.752	0.753	0.753
550		0.831	0.797	0.766	0.774	0.758
600		0.861	0.820	0.781	0.787	0.776
650		0.874	0.867	0.835	0.789	
700				0.866	0.842	0.804
750					0.851	0.861

ranged between 0.756 and 0.874. The gasoline or motor fuel from thermolizing a paraffin base oil is a mixture of paraffins, olefins and aromatic hydrocarbons and the specific gravity must necessarily be higher than if simply paraffins were present. The percentage of hydrocarbons boiling below 150 deg. C. increases with increase of temperature as does also the specific gravity. With increase of the rate of oil flow, the percentage usually reaches a maximum and then decreases as does also the specific gravity values.

H. GASOLINE ON BASIS OIL USED FOR PRODUCTION
TABLE XIII

Rate, gals. per hr. . . .	6	12	16	23	30	36
Temperature, Deg. C.	PERCENTAGE GASOLINE					
400	15.4					
450	12.2	13.4	18.1	8.8		
500		15.7		14.8	18.1	12.9
550		12.9	16.3	13.9	17.1	12.0
600		12.0	16.2	12.6	16.3	17.8
650		7.1	13.1	13.5	13.9	
700				11.6	13.9	16.9
750					15.4	14.9

The maximum percentage formation of gasoline from the paraffin base oil used was 18.1 at 450 deg. C. and 16 gal. per hour and also the same per cent at 500 deg. C. and 30 gal. per hour. This emphasizes the close relationship of the temperature and rate of oil flow. By increasing the temperature 50 deg. C. almost double the amount of oil could be cracked in the same time to form gasoline.

I. PERCENTAGE OF OLEFINS IN THE GASOLINE CUT
TABLE XIV

Rate, gals. per hr. . . .	6	12	16	23	30	36
Temperature, Deg. C.	PER CENT BY VOLUME					
400	29.2					
450	19.6	28.6	26.9	27.1		
500		33.1		22.3	33.0	30.5
550		15.8	22.2	34.4	29.0	33.0
600		10.5	18.0	31.5	26.2	29.1
650		5.8	8.7	18.2	25.0	
700				9.9	11.4	24.0
750					11.3	12.2

Table XIV tabulates the percentage of olefins in the various gasolines obtained. These values are important in determining the amount of refining necessary to purify the motor fuel, sulphuric acid being usually used for that purpose.

SUMMARY

1. A paraffin base oil was subjected to temperatures ranging between 400 deg. and 750 deg. C. and rates of oil flow from 6 to 36 gal. per hour at 150 lb. per square inch.

2. The percentages of unsaturateds in the distillation cuts of the cracked oils were determined. These cuts were as follows: To 95 deg. C.; 95 to 120 deg. C.; 120 to 150 deg. C.; 150 to 170 deg. C.; 170 to 230 deg. C.; 230 to 270 deg. C.; 270 to pitch.

3. It is important to note the low temperature of

400 deg. C. for the formation of toluene and xylene from a paraffin base oil which had a boiling point range of 95 per cent between 200 deg. and 350 deg. C. The temperature of cracking was but slightly above the highest boiling point constituent of the starting oil. Benzene formed to the extent of 3.8 per cent in the recovered oil at 450 deg. C. and rate of oil flow of 6 gal. per hour.

4. A hypothetical mechanism of aromatic hydrocarbon formation from the decomposition products of the paraffin oil has been given.

5. The maximum percentage of 6.6 for benzene on the basis of oil used occurred at 650 deg. C. and 16 gal. per hour. For toluene the percentage of 4.5 at 750 deg. and 36 gal. per hour and for xylene 3.4 per cent as a maximum occurred at 600 deg. C. and 16 gal. per hour.

6. The maximum percentage of 18.1 for gasoline formation on basis of oil used occurred at 450 deg. C. and 16 gal. per hour and also at 500 deg. C. and 30 gal. per hour. That is, by increasing the temperature 50 deg. the capacity factor increased almost 100 per cent.

7. The percentage of olefins in the gasoline cut ranged between 5.8 and 34.4.

8. The maximum percentage formation of the total aromatic hydrocarbons benzene, toluene and xylene of 12.7 on the basis of oil used was found at 750 deg. C. and 36 gal. per hour.

9. Since, as stated in the introduction, one of the objects to be ascertained in this paper was the relative value of different hydrocarbons for the formation of gasoline, unsaturateds and aromatics the results obtained from a naphthene base oil in a previous investigation have been compared. The naphthene base oil run under comparable conditions yielded uniformly higher percentages of end products as shown in the following table, giving maximum yield conditions of the two type oils:

Wiegloff, Twomey and Moore, MET. AND CHEM. ENG., 15, 387, 1916.

	NAPHTHENE OIL		PARAFFIN OIL	
	Per Cent by Volume	Temperature of Run, Deg. C.	Per Cent by Volume	Temperature of Run, Deg. C.
Benzene	7.2	650	6.6	750
Toluene	6.0	650	4.5	650
Xylene	8.1	600	3.4	600
Total aromatics: Benzene, toluene and xylene	18.2	650	12.7	750
Gasoline	26.2	600	18.1	450
Olefins in gasoline cut.	28.1	600	29.9	450

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Lead Output in Missouri for 1915.—In 1915 Missouri supplied the world with 36 per cent of the lead ore mined in the United States, holding first rank for an output of 160,105 tons. The total lead ore output for the year in the United States was 537,012 tons. This large output was mainly due to the great demand caused by the European war. The lead ore output for 1913 was 436,430 tons, in 1914 the United States supplied 534,482 tons, showing that the increased output for the year 1915 was 2530 tons over that of 1914 and 100,582 tons over that of 1913. The average value of lead for the year 1915 was 4.7 cents per pound or \$94 per ton. The Missouri ores also contain a small amount of silver, but it requires high-grade refining to desilverize the lead. Three Missouri smelting and refining companies now are equipped with desilverizing departments, which save the 1 per cent of silver found in the ore, which formerly was not recovered.

The Chemical and Physical Properties of Foundry Irons

By J. E. Johnson, Jr.

Irons were formerly, and to some extent still are, graded by their fracture from No. 1 to No. 6—No. 1 being the most coarse grained and graphitic iron and No. 6 being a solid white iron entirely without graphite. The No. 2 and 3 grades are nearly always divided into No. 2-X and No. 2 plain, and No. 3-X and No. 3 plain. Number 4 is commonly called "gray forge," No. 5 "mottled," and No. 6 "white," this grading corresponding with the fractures of the iron, and the fracture in turn being supposed to correspond with the softness of the iron in use.

Up to about twenty or twenty-five years ago chemical analysis was not used to any important extent in determining the quality of foundry iron, and this grading by fracture was the only method available to the foundrymen for determining the suitability of different irons for different purposes, but in more recent years it has been found that this grading corresponded in a general way with the presence of silicon and the absence of sulphur, and chemical specifications became finally to be used as supplementary to the fracture, and now to a very large extent have replaced fracture altogether in the purchase and sale of coke irons. The Eastern Pig Iron Association has adopted the following specifications as corresponding to the three grades first mentioned:

	Silicon	Sulphur
No. 1X	2.75—3.25	0.04
No. 2X	2.25—2.75	0.045
No. 2 Plain	1.75—2.25	0.05

The relations between chemical composition of irons and their physical characteristics are vital in foundry irons and there have been until recently wide gaps in our knowledge of the subject which are not yet completely filled but which have been greatly reduced by investigations made in recent years. In October, 1914, I delivered an address before the Franklin Institute in Philadelphia in which I embodied the latest developments of our knowledge of this subject. The principal recent development was the discovery of the important effect of oxygen on the physical qualities of the irons in which it is contained. These effects are for most purposes highly beneficial, and for others very detrimental, and they explain many facts, the reasons for which had been mysteries previous to this discovery.

Following the discovery, methods were developed for introducing oxygen artificially into iron and some of the results obtained by this process are given as a part of the subject of the quality of iron, and are included in the article above mentioned, which is quoted here practically in full.

Nearly all the chemical work and most of the microphotographs made during the investigations of which this paper is the result were made by Mr. L. Selmi, then chief chemist at the Ashland plant, now chief chemist and metallurgist of the River Furnace Company's steel plant. In addition Mr. Selmi gave his hearty and sympathetic co-operation to the whole investigation and rendered invaluable service to it throughout.

Founding is one of the early arts and undoubtedly had its origin at the time of the development of the blast furnace in the latter middle ages. It has made its greatest progress, however, since the methods of using mineral fuel in this furnace have cheapened the product of the latter so much that 90 per cent or more of that product is now nothing more than the raw material for the production of steel. The art of founding was almost ignored by the scientific metallurgist until

within comparatively few years. The developments in the manufacture of steel were so rapid and of such vast importance to the whole of mankind that practically all the labors of iron and steel metallurgists were devoted to steel, and the foundryman was left to struggle along as best he could on the basis of his hard-earned, and sometimes contradictory, practical knowledge and experience. In the nineties of the last century was brought about a great change in this condition, for chemistry began to be applied freely in the foundry, and by its aid many facts in connection with the manufacture of cast iron were brought out. Some of these facts the practical men declared were not true, and the conditions of cast-iron manufacture are so complex that many are still in dispute.

In 1900, the closing year of the decade referred to, I published in the *American Machinist* an article in which, to my mind, was made the first definite and coherent statement of the nature of cast iron, particularly in its relation to steel. The following are some quotations from this article:

... the key to the subject lies in considering cast iron and steel not as entirely separate and distinct, but as the same substance, passing by infinitesimal gradations from the chemical and physical properties of one extreme to those of the other. The probable reason that this fact is not more widely realized than it is, is that both of the extreme conditions are "soft"—soft gray iron and soft or mild steel—while the connecting link between them is the hardest of tool steel at one end and the hardest of white iron at the other, with no sharp lines separating them from one another.

There is no doubt that there could be made in a blast furnace, from the proper materials, an iron containing silicon 0.2, manganese 0.4, phosphorus, 0.03, sulphur, 0.03, combined carbon 2.75 per cent, graphitic carbon, trace.

But excessively hard crucible steel may be made having precisely the same analysis, and both have practically the same properties. The crucible steel is so hard and brittle that it cannot be commercially rolled or hammered, and is of no value, as well as being extremely difficult to make, while the greatest care and effort, and probably several weeks or even months of trial, would be necessary to produce an iron with the composition given, in a blast furnace, and when produced it would be of little commercial value; so that a material having this composition is seldom or never produced—never commercially—and we are not, therefore, familiar with it, and do not realize the fact, which it is impossible to emphasize too strongly in this connection, that it exists, or may exist, and constitutes a perfect link between cast iron and steel.

Since soft iron contains the most total carbon (about 4 per cent) and very mild steel the least (say, 0.06 per cent), while the intermediate stage, the very hard iron or steel just described, contains about the average of these two, roughly speaking, and is so much harder than either as not to resemble them in its properties, this may be thought to weaken or invalidate the above statement; but it does not, when properly considered, for, while the total carbon is high in the cast iron, almost all of it is in the graphite form and only a trace is combined.

If we say, "Cast iron and steel are alloys of the chemical element iron with carbon, with a chemical and physical admixture of other compounds, and the hardness of the alloy depends, within commercial limits, upon the amount of the carbon in it, while its tenacity, ductility, and other physical properties depend upon the other substances present, and upon the physical treatment it receives, and the variations produced by these are approximately the same in both," we shall have a blanket definition of the two substances which covers both quite fully and with substantial accuracy.

Too much stress can hardly be laid upon the two kinds of carbon in cast iron, the "combined" being chemically united or combined with the iron to form a chemical compound; the other, the graphitic, being merely interspersed among the grains or crystals of the iron. The most striking proof of this latter is that shown a few years ago, I have forgotten by whom, which consists in brushing with a steel-wire brush the fractured face of a pig of gray iron, one-half of which is protected from the action of the brush: the brushed half becomes perfectly white, like white iron, although the grain, of course, remains as before. The unbrushed half, of course, shows the contrast more plainly.

Iron, when hot, has a far higher capacity for dissolving carbon and retaining it in combination than it has when cold. The graphitic carbon is probably all in solution at first, although this is not certain. But as the iron cools, if it cools slowly, the graphite is forced out and what is near the surface flies off into the air. It can be seen doing it at a blast-furnace cast when the iron is of the proper composition. The rest is retained, immersed in the grains of the iron, and probably gives to gray cast iron whatever toughness and flexibility it possesses, separating the grains or crystals from continuous contact and lubricating their movements.

Thus hard cast iron, while much less flexible, is much more elastic than soft, as it should be, having much less graphitic carbon in it. The more slowly the iron cools the more graphite crystallizes out of it and the larger the crystals, so that comparatively hard iron, when cast into large masses and allowed to cool for several days, or longer, will show a grain which would put "No. 1 X" to the blush.

The tendency to eject carbon and become softer, in consequence, does not by any means stop when the iron is solid, nor until it is down to the lower limit of the red heat at least, and how much lower the writer will not undertake to say. When any casting was made from moderately hard iron which it was required to machine, it was always kept carefully covered up until dead cold, and this was known by experience to be very necessary. Some intentionally "chilled" pieces, when made of very hard iron, would "fly" off themselves from the cooling strains set up, but could often be saved by keeping them hot as long as possible.

When the iron is cooled suddenly, the carbon does not have time to separate out, and remains combined with the iron, making it "white" instead of gray, because of the absence of the black graphite.

I think that this is a reasonably good presentation in a broad way of our knowledge of the subject to-day. It is a matter of interest that, in the subsequent part of the above article, is to be found the statement that the only reason for the use of charcoal iron, particularly for chilling purposes, was that, charcoal being free from sulphur, iron as low in silicon as desired could be produced in the charcoal furnace without any important simultaneous increase in the sulphur above that in high silicon iron, which could not be done in coke furnaces until shortly before that time, but that it could be done then at will, and that charcoal iron had accord-

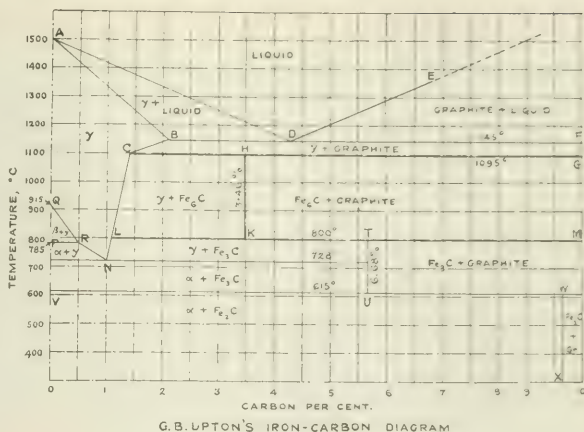


FIG. 2

ingly no advantage over coke iron, and was destined to pass out of use. This is probably as good an illustration of assuming that all the facts fit an incomplete theory and drawing a totally erroneous conclusion in consequence as you will find anywhere in technical literature, and it is my particular purpose to point out the important respect in which charcoal iron differs fundamentally from coke iron, and to describe the method by which we have succeeded in obtaining, for a modified form of coke iron, the advantages of charcoal iron in a greater degree than are obtainable by it.

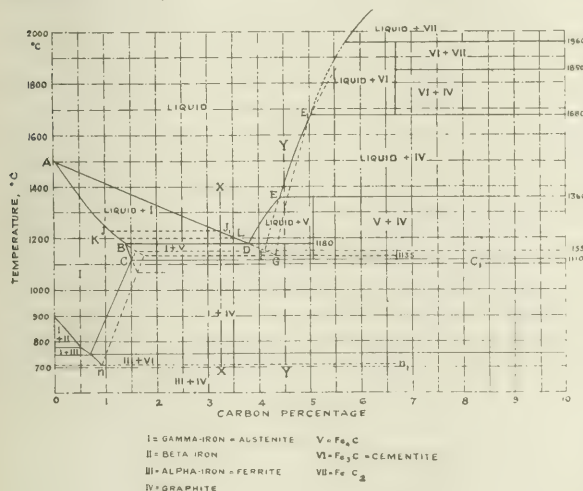
In 1901, the year following the publication of my article, Prof. Henry M. Howe read a paper before the American Institute of Mining Engineers, in which the theorem of the continuity of the cast iron-steel series was set forth more elaborately and in far better language than in mine. Professor Howe pointed out that the important question in regard to the carbon in cast iron is not what is the total carbon, nor yet how much is thrown out as graphite, but how much is *left combined*, because it is upon the quantity of combined carbon in the matrix that its strength depends.

It seemed to me at first that this statement put the matter in a nutshell, and was obviously correct. It will be seen later that Professor Howe's is also an incomplete theory, and that certain other factors enter in of so much greater importance in the final result as almost to eclipse the truth contained in his statement taken by itself.

From the quotations I have made, it is obvious that cast iron must be considered primarily as an alloy of iron and carbon. This is quite proper in a more elementary sense, because carbon is present in iron quantitatively to a greater extent by weight and to a far greater by volume than is any other element. Carbon has, moreover, a more powerful effect, weight for weight, than any other element except one.

The Iron-Carbon Diagram

The iron-carbon diagram, as applied to cast iron by Guertler based upon researches of Wittorff, is shown in Fig. 1. In Fig. 2 is shown a similar diagram drawn by Upton. Both of these have been obtained through the kindness of Prof. William Campbell, of Columbia University. All are probably familiar



GUERTLER'S IRON-CARBON DIAGRAM

FIG. 1

with the general form of these diagrams. The abscissæ represent percentages of carbon, and the ordinates temperatures. The diagram, within its range, attempts to set forth the changes which occur in any solution of iron and carbon. A horizontal line runs across at the temperature of 1180 deg. C., and two diagonals drawn respectively from the upper right- and left-hand portions meet upon this line at the point corresponding to 4.2 per cent of carbon in Upton's diagram, at 3.8 per cent in Guertler's. The diagrams attempt to show not only equilibrium conditions—that is to say, those conditions which prevail after the mass has been allowed sufficient time in cooling to reach a complete state of equilibrium—but also metastable conditions.

The interpretation of certain of the transformations is extremely difficult. I will not try at this point to make an exposition of the complete diagram, but will only call attention to its salient features. Considering Guertler's diagram and starting with a molten solution above the diagonal line on the left-hand side, we have a homogeneous solution—let us assume one whose composition is represented by the line *XX*. When the temperature falls, the composition remains constant until point *A* is reached, when, if ample time be allowed for the cooling, a solid freezes out, whose composition at any temperature is given by the intersection of the horizontal through that temperature with the line *AB*, in the present instance the line *JJ*, shown on the diagram. The metal represented by the point *J* obviously contains less carbon than that of the whole mass represented by the abscissa of the line *XX*, and the carbon rejected by this solution in freezing must go over into the remainder of the solution, and so increase its carbon. If sufficient time is not allowed in cooling through any range, for instance that from *JJ*, to *KL*, the carbon from the solution is not able to diffuse into the solid and bring the percentage up to that represented by the point *K*, but tends more to follow the vertical line from *J* to *K*. This takes less carbon from the solution and leaves the excess in it greater. We have, therefore, the curious condition that the more rapid the cooling the greater the difference in carbon contents of the first and last frozen portions of the original metal.

After the metal has fallen in temperature below the line *BD*, it is entirely solid, but is not yet in its permanent condition, because carbon tends continually to fall out of solution. The method by which this takes place is subject to various conditions, and is not yet fully understood, even among the scientists who deal with this phase of the subject, as will be clearly seen by the difference between the lower portions of Fig. 1 and Fig. 2, which are intended to represent the same set of objective phenomena.

The following brief statement of the possibilities in regard to the transformation of these points is quoted from my reply to the discussion of my paper, "The Effect of Oxygen, etc.," before the Institute of Mining Engineers, published in its *Bulletin*, June, 1914, and was prepared for me by Professor Campbell, through whose kindness I am able to present here three possibilities based on the work of Guertler (who founds his conclusions upon the experiments of Wittorff and Ruff) and one based on Upton's iron-carbon diagram. According to Guertler:

I. In the stable condition above 1360 deg. C. and 4.4 per cent C., we can have liquid + graphite.

At 1360 deg. C. the reaction occurs; liquid + graphite = Fe_3C , and in alloys with 4.4 per cent carbon down to 3.8 per cent we find Fe_3C crystallizing out from the melt.

At 1180 deg. C. we have the eutectic of austenite + Fe_3C .

At 1110 deg. C. Fe_3C breaks up into austenite + graphite.

At 750 deg. C. the eutectoid of ferrite and graphite forms.

These are equilibrium conditions which are reached only with extremely slow cooling.

II. With more rapid cooling, the reaction at 1360 deg. C. does not occur. Graphite separates from the melt, and at 1155 deg. C. we get the eutectic of austenite + graphite.

III. With more rapid cooling, Fe_3C separates out from the melt and at 1135 deg. C. and 4.3 per cent carbon forms a eutectic with austenite; then at 710 deg. C. we have the eutectoid Fe_3C + ferrite, commonly known as pearlite.

According to Upton's diagram, white irons are supersaturated solid solutions which are breaking down; and the stable constituents are austenite + graphite above 1095 deg. C.; austenite + Fe_3C or Fe_2C + graphite below 1095 deg. C.; and at 800 deg. C. Fe_3C appears while Fe_2C disappears. At 600 deg. C. Fe_3C breaks down into Fe_2C . Fe_3C and Fe_2C have yet to be distinguished from Fe_3C under the microscope.

Leaving this for the present, let us consider the conditions represented by an iron-carbon alloy, containing more carbon than that represented by the point *D* on both diagrams. Assume, for instance, iron of a composition represented by the line *YY*. According to both diagrams, when the temperature has fallen to the point where line *YY* cuts the right-hand branch of the curve solidification begins; but in this case it is either Fe_3C , graphite, or Fe_2C which is thrown out of solution.

The relationships expressed by the dotted lines *FE* and *GE*, are too obscure for description at this point, though we may revert to these briefly after examining the action of a few of that infinite variety of alloys answering to the comprehensive name of "cast iron."

In either case, it is well to remember that, when the temperature falls slowly, the iron tends to follow the one or the other of the branches of the curve in cooling. If a hypoeutectic iron—that is, one lying to the left-hand side of the point *D* (for instance, the composition represented by the line *XX*),—selective freezing tends to take place along the line *AB*, with a resulting concentration of carbon in the mother liquor, represented by the distance between the lines *AB* and *AD* on the horizontal line corresponding to the given temperature. But if sufficient time be not allowed then the iron tends to freeze in a purer (that is, lower carbon) condition, with a greater enrichment in this element of the mother liquor.

On the other side of the eutectic point *D* the hyper-eutectic iron tends in freezing to follow along one of the lines *DE*, *FE*, or *GE*, and in any event this corresponds to the falling out of graphite, or a carbide which, being richer in pure carbon, leads to a direct proportional impoverishment of the mother liquor; and this impoverishment in this case is greater if time is allowed for full equilibrium to be reached, and less if this time is shortened.

When the whole mass has solidified, it is at the temperature represented by the points *D*, *F* or *G*, and consists of a mixture of different constituents, and the character of this mixture depends upon the original composition of the iron-carbon alloy and its rate of cooling from its initial temperature to that of the freezing point. This mixture generally contains graphite physically enmeshed, if it be a hyper-eutectic iron.

Below the line *CC*, it is obvious, from the diagrams, that their authors disagree considerably as to the details of the action, but further graphitization goes on, and the solution of pure iron in cementite becomes poorer and poorer in carbon until the line *nn*, is reached,

when a very important transformation takes place. All the solid solution remaining breaks up into pure cementite in all detached areas and into pearlite, one of the best known constituents of all irons and steels, and one which can perhaps best be described by reference to the fact that 0.9 carbon steel, in its unhardened condition, consists entirely of this material. Pearlite is well known as one of the strongest and toughest of the countless combinations of iron and carbon.

Even at this low temperature, 725 deg. C. or 1337 deg. Fahr., barely a dull red, the iron is not yet in equilibrium. The cementite may break down to pure iron and graphite in relatively large masses. Pure iron or ferrite is only about one-third as strong as pearlite, and, of course, when its continuity is broken up by graphite it is thereby further weakened, and, being in large areas, its effect in weakening the whole structure is very great.

The line *DE* of Upton's diagram may be entirely disregarded, since it is well known that the actual line is much steeper and is probably, nearly if not exactly, as drawn on Guertler's diagram, which is more recent than that of Upton and is based on the researches of Wittorff, the most recent and probably the most accurate of any of the investigations on high-carbon alloys of iron.

Upton's diagram is shown principally for the reason that it contains the vertical line *HK*, since it has been found by actual experience that irons with more than a certain quantity of carbon graphitize to a much greater extent than similar irons containing less carbon, and that high carbon irons not only throw out more graphite than do lower carbon ones, but the combined carbon remaining is very materially less in the high carbon irons than it is in the low. The line *HK* indicates such an action, and is, therefore, to some extent in agreement with the observed facts, although I am quite unable to state whether the exact location of the line at 3.46 per cent carbon is correct.

From the point of view of practical value, two possibilities according to these diagrams stand forth prominently.

1. Graphite can separate directly from the melt. This is contrary to the claims of Professor Howe and Professor Sauveur, but is abundantly supported by the facts. Their contention that this action can take place only through the prior formation of cementite is completely negated by facts of practice which are matters of common knowledge to furnacemen.

2. After solidification, according to Guertler and Upton, in certain areas of the diagram a very slight change in conditions may cause a complete change in the resulting product.

The iron-carbon diagram gives graphically the best information we have concerning the action of alloys of pure iron and carbon, but cast iron is far removed from that theoretical material, as it contains, in addition, silicon, sulphur, phosphorus, manganese, and sometimes oxygen, generally, if not always, in vastly varying quantities. There may be also titanium, vanadium, chromium, nickel and perhaps many other elements present, but the first five are the important ones in commercial pig irons. Each of these exercises its principal action upon the carbon and upon its condition, and as a result we would need in practice a complete diagram of the form given for each. To represent graphically, for instance, the effect of carbon and silicon together, we would require a figure of three dimensions, or, in other words, a solid or "glyptic model." In addition, for each percentage of each of the other elements there would be a variation of this model to express all the facts. The effect of three elements would occasion a model of four dimensions. As matter of

fact, however, we have not as yet sufficient information to make a single iron-carbon diagram with absolute certainty, nor do we know very definitely the quantitative effects produced by given quantities of the other elements I have mentioned. We must needs, therefore, confine ourselves to a consideration of the qualitative effects of the above elements on the iron-carbon solution.

The Shape of the Graphite and the Form of the Crystals

Before dealing with the effects of the other elements, I wish to call attention to two profoundly important facts, no intimation of which can be found in the iron-carbon diagram and the effects of which cannot be recorded upon it. They are, however, of vast industrial and, I think, scientific importance, and are also two factors in the final result to which I shall have occasion to refer frequently. The first is the shape of the graphite particles, and the second the form of crystallization in which the iron solidifies.

The shapes in which graphite can occur vary immensely, and have a corresponding effect upon the structure as a whole. Graphite is, to all intents and purposes, a foreign substance in iron. In other words, we could make a steel of the same composition as a good cast iron, counting only the combined carbon, and could by suitable heat treatment bring the combined carbon into the same condition as in cast iron, and have a homogeneous material of the same nature but free from these particles of a virtually foreign substance; this would constitute an impure steel.

The smoothness and lubricating qualities of graphite are well known, as is also the fact that it is entirely without physical strength. To intersperse flakes of this material thickly through cast iron can have obviously no other effect than to break its continuity and destroy the bonds with one another of the particles of iron proper. Good gray iron contains about 3.0 per cent of graphite, and the specific gravity of this is about a fourth that of iron. This corresponds to about 12 per cent by volume.

One of the things which we have discovered is that graphite in some iron is of extreme thinness and of vast extent, while in other iron it exists in scarcely more than little round knots or balls. Consider this enormous percentage by volume and the extreme thinness of the plates of graphite, which, judging from the photomicrographs, are probably less than 1/1000 of an inch thick, and you will see what an enormous area they must have to make up 12 per cent of the volume, and what a vast amount of damage they must do to the structure of the iron.

If we were to make up concrete and add to it 12 per cent by volume of, say, tin scrap in small, irregular pieces, about 1 in. across, and well greased to prevent the concrete from adhering to them, and were to stir these thoroughly through the mass, and then pour the mixture into a form, do you think that the resulting concrete would be particularly valuable? If, now, instead of tin scrap an inch across, we used iron balls of about the same specific gravity and to the same extent by weight, and stirred those thoroughly through the mass, can you doubt which concrete would be the better?

As to the form of crystallization, the eutectic of 4.20 carbon crystallizes from a pure iron-carbon solution in a series of flat plates, the cross-section of which is similar to that of a number of fern leaves laid side by side, as shown by photomicrographs, Figs. 3 and 4. In certain kinds of iron these plates grow so large as to be plainly visible to the naked eye. When they remain

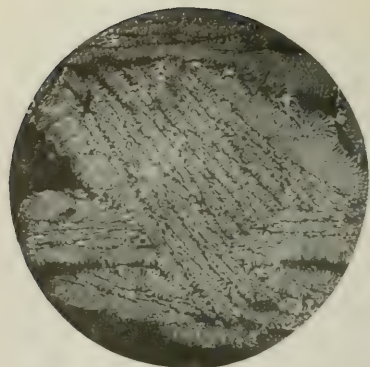


FIG. 3—ETCHED (MAGNIFIED 38 DIAMETERS) SPOT OF SPOTTED IRON

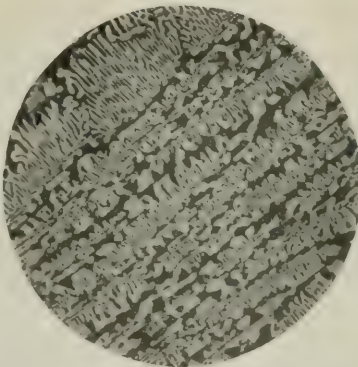


FIG. 4—ETCHED (MAGNIFIED 100 DIAMETERS) SPOT OF SPOTTED IRON

white, they are as smooth as if polished, and shine brilliantly when their surfaces are exposed. If you imagine a series of blocks of mica thrown loosely into a mold, and a cement or glue poured in to fill up the spaces between, and the resulting structure subjected to stress, you would not expect to find it very resisting, no matter how good the cement, because the blocks would cleave apart on the smooth faces of the mica. It is the same with iron which has this crystallization. No matter how good its chemical composition may be, even if the combined carbon be of the exact amount to give the greatest strength, the iron will be weak and worthless.

If, on the other hand, even the concentration which comes from progressive freezing results in the formation of little or no eutectic, the solution freezes into a network structure, which I have supposed is the same as that in the steel named by Professor Howe "Primaustenoid." The best illustration of this structure I have is that shown by Figs. 5 and 6. I think you will see that the structure as a whole is vastly more homogeneous than the eutectic and quite lacking in the lines of cleavage which give the latter its bad qualities, but that such lines of crystallization as do appear are in the form of a meshwork, so that the whole structure, where not absolutely homogeneous, is interlaced together.

These are the two facts which render the amount of graphite, and even the percentage of combined carbon, matters of secondary importance, and which minimize the value of Professor Howe's brilliant generalization on that subject.

The qualities by which different irons are distinguished from one another are very many. I have classified them as follows: strength, flexibility, elasticity, density or closeness of grain, fluidity, freedom from shrinkage, and machinability. These represent qualities generally desirable, but the importance of some is the greatest in one class of work and of others in other classes of work; in fact, advantages for one class of work may be positive disadvantages for another. These are matters which depend upon the purposes for which the castings are to be used, and need not be discussed in detail here.

Let us return now to the elements of prime importance—carbon, silicon, sulphur, phosphorus, oxygen, and manganese—and con-

sider the effects which varying quantities of each of these may have upon each of the above qualities of major importance. You will see that we have here a practically unlimited number of combinations, and that it is virtually impossible to do anything more than to discuss the general results of the variations of the elements within the range of practice in different lines of foundry work.

Carbon

The subject of the effect of variations of carbon on cast iron has been neglected far too much. The carbon

determination in cast iron is a difficult one, and unless made by a man with considerable experience along this line is of no value. Errors to the extent of 1 per cent of the weight of the iron (not the carbon) have frequently been made by good and conscientious chemists through the difficulty of manipulation and, until recently, through the absence of suitable apparatus for the purpose. At the Ashland plant of the Lake Superior Iron and Chemical Company, where the researches whose results I am about to give you were begun, we introduced a long silica tube heated by an electric resistance coil, with a pyrometer to control the temperature, and burned the carbon in a stream of purified oxygen, catching the carbon dioxide in barium hydrate solution and determining its amount by titration—practically the same method as used for carbon in steel. We became so convinced of the importance of carbon determinations that we put an extra man into the laboratory in order to obtain one on every cast. Even with this excellent apparatus it took months to learn necessary temperature control and other precautions which must be taken to secure correct results. The difficulties are greatly increased by the fact that one iron will be heated to incipient fusion and sintered by a given

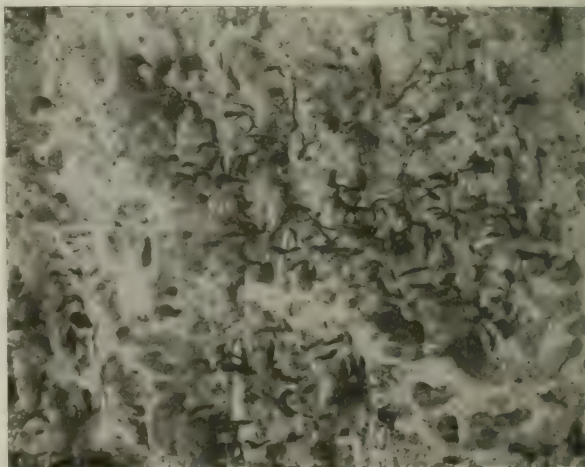


FIG. 5—ETCHED (MAGNIFIED 100 DIAMETERS) GOOD CHARCOAL IRON, SHOWING MESHWORK STRUCTURE

temperature, thus sealing up some of the carbon and giving a low result, while another iron at the same temperature may not be hot enough to give off all its carbon and may show a low result on that account. I believe these difficulties of making carbon determinations at all, and of securing dependable results when they are made, have militated more against the progress of cast-iron metallurgy than any other factor.

The results of variations in carbon and their effect on the form of crystallization were set forth at some length in a paper by myself, read before the American Institute of Mining Engineers and published in 1912, entitled "Effect of High Carbon on the Quality of Charcoal Iron."

The results we obtained have been briefly mentioned above, and were that iron of the eutectic ratio crystallizes in smooth, flat plates without cohesion between either the plates in one group or between those of one group with those of another. If the iron is above the eutectic ratio—that is, of a composition represented by the right-hand branch of the iron carbon diagram—the excess carbon above the eutectic ratio falls out in the form of graphite as the iron cools along one of the lines *DE*, *FE*, or *GE*, and in that event, of course, the whole mass, except the ejected graphite, is at the eutectic ratio at the point of solidification and freezes as a mass of eutectic, perhaps interspersed with the particles of hypereutectic graphite. During cooling after solidification, if the silicon be high enough it forces the decomposition of the eutectic plates into ferrite, pearlite, and graphite. These are formed in the solid condition and necessarily have the orientation of the plates of eutectic from which they are born, and, in consequence, high carbon irons, when they have sufficient silicon to make them gray, have an appearance of high cleavage, especially around the corners of the pigs and at other points where they are quickly cooled. These cleavage planes are black or gray, but are of the same general character as the brilliant white plates, which occur in the same iron when it is white or mottled. They are the result of the breaking down or graphitization of the original eutectic plates (Figs. 7 and 8).

These irons have been noted for a curious peculiar-

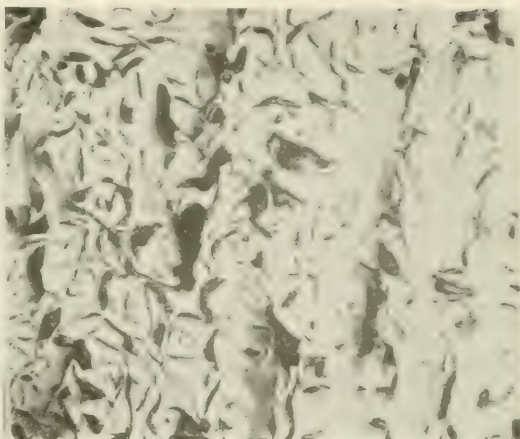


FIG. 7—UNETCHED (MAGNIFIED 70 DIAMETERS) HIGH-CLEAVAGE IRON, SHOWING ROWS OF GRAPHITE FLAKES ORIENTED AFTER EUTECTIC PLATES FROM WHICH THEY WERE FOCUSED

ity; ordinarily we expect to see the part of the iron cooled white first and the part last cooled gray, if there be any white or any gray at all, which means that the white is outside and the gray is in the center. But in these irons the outside of the pig is gray, while there is a white chilled spot in the center, or just above the center, of the pig (Fig. 9). This curious phenomenon has caused much racking of wits, especially during the course of our investigation at Ashland.

Finally, it occurred to me that this spot occupied the position which a segregate would take. An analysis of the spot and other portions of the pig showed that there was indeed a segregation. In irons of moderate carbon, the portions first frozen are well below the eutectic ratio, but the portions last to freeze have the carbon concentrated in them by the selective action of freezing and therefore crystallize in the eutectic form. It is well known that the evolution of graphite is accompanied by a considerable increase in volume, and, if this be resisted with sufficient pressure, graphitization cannot take place, and the iron must remain white. I have seen a white spot produced in the center of a pig

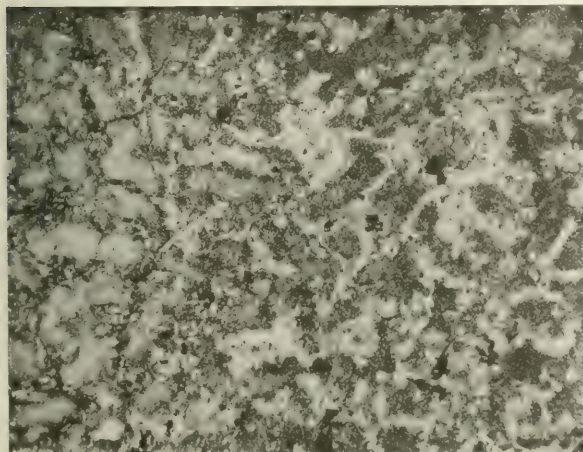


FIG. 6—ETCHED (MAGNIFIED 100 DIAMETERS) COKE IRON WITH OXYGEN ADDED. FIRST HEAT OF JOHNSON IRON EVER MADE. (PHOTOGRAPH DUE TO KINDNESS OF PROF. WILLIAM CAMPBELL)

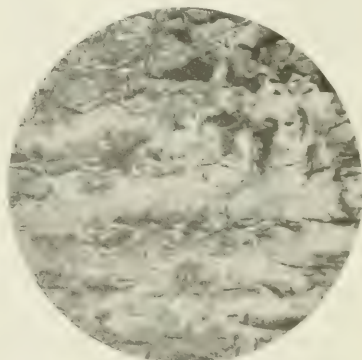


FIG. 8—ETCHED (MAGNIFIED 70 DIAMETERS) SAME AS FIG. 7

of good iron by cooling the exterior very rapidly. This took away the heat from the outside, while the center still remained hot enough to retain its carbon in the combined condition. The resulting contraction of the outer metal prevented the graphitization of the center, which would have taken place as the temperature fell, by preventing the necessary increase in volume.

It has previously been suggested by Mr. H. E. Field that this spot was caused by the pressure resulting from the contraction of the outer shell of first frozen metal upon it, but, as all pig iron solidifies under these conditions and only a small portion of it contains this spot, this solution was obviously inadequate.

The reason for the automatic formation of the white spot in these spotted irons is probably to be found in two factors:

First.—The segregate at the center is the eutectic, and therefore has a freezing-point very decidedly lower than the outside, so that the shell is thoroughly solidified and able to exert a considerable pressure when the center is still molten.

Second.—These spotted irons occur only within a limited range of silicon, from 0.8 per cent down to 0.3 or 0.4. The former limit of silicon is sufficient to force graphitization, even against the resistance of the external shell. Below the latter limit the iron is practically all white, although in the case of a high carbon iron it may be heavily specked with primary graphite scattered between the blocks of eutectic plates which constitute the body of the structure.

In regard to spotted iron, it is a matter of observation that an iron may show a "spot" if quickly cooled, but will not do so if cooled slowly. For instance, the 1½-in. test bars made at every cast at Ashland would sometimes show a spot when the pigs did not. This is evidently because of the fact brought out in the explanation of the iron-carbon diagram that the quicker the cooling and the less time allowed for the diffusion of the carbon into solidified portion of the metal, the greater the carbon concentration in the last frozen portion. Iron which, when slowly cooled, is far enough below the eutectic ratio not to undergo sufficient carbon concentration to show a "spot," undergoes, when quickly cooled, a greater carbon concentration, because there is not enough time allowed for the diffusion of the carbon throughout the mass, and so shows a spot.

These high carbon irons were noted among practical men for very deficient chilling power, a fact amply confirmed by observation of the "chill pig" at Ashland, of which one was cast in every bed, these irons having only a fraction of the chill which they should have for a given silicon. This action, may, I believe, best be explained by reference to the well-known law of physics, that a solution of, say, common salt may be cooled below the point at which it can theoretically retain the amount of salt which was dissolved at a higher temperature, and may, if kept quiet, retain the excess to a temperature considerably lower than that of equilibrium; but if a single crystal of salt be dropped into the solution, the excess will instantly crystallize out around it, and the solution will at once drop to the equilibrium ratio. So in iron, if it be cooled more rapidly than will permit it to reach equilibrium, under ordinary conditions more carbon will be retained in combination than the equilibrium ratio would call for, but when the mass is filled with graphite flakes deposited from the molten condition (which, as I have explained, takes place with these irons) these graphite flakes act as centers of precipitation and cause more carbon to fall out of the solution than would do so if there were less total carbon present. Thus, by the aid of the microscope and with a little help from the iron-carbon diagram, we find the

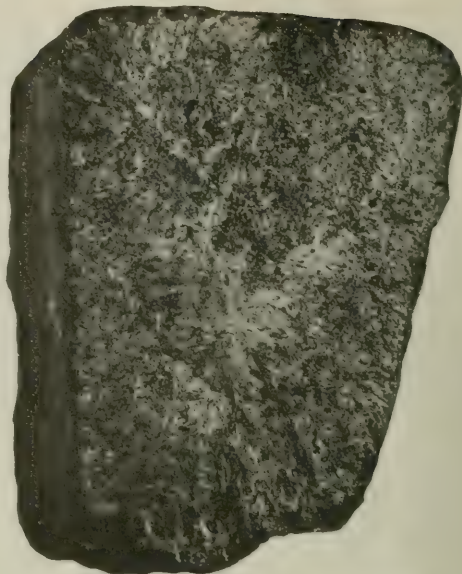


FIG. 9—TYPICAL FRACTURE OF "SPOTTED IRON"

explanation for the characteristics of these irons easily translatable into terms of analysis, namely, their high carbon content, and so solve this long-standing riddle.

In this connection, it must be pointed out that, while 4.2 per cent is the eutectic ratio for a pure iron-carbon alloy, the eutectic point is lowered by the addition of silicon, and probably reaches to 3.8 per cent or even lower when the silicon reaches about 2 per cent or more. On the other hand, other things being equal, the total carbon falls as the silicon rises beyond, say, 0.5 per cent, because carbon and silicon exert to some extent a mutually exclusive action upon each other, exactly as water saturated with calcium chloride will not take up as much common salt at a given temperature as will pure water. So, as the silicon in iron rises, the carbon falls until we reach "silvery iron"—which is a much lighter gray than ordinary iron because of the small quantity of carbon present, in spite of its being entirely graphite, the carbon with 4 per cent silicon probably falling to below 3 per cent, as against nearly 4 per cent in coke iron, and sometimes almost 5 per cent in spotted charcoal iron of about 0.5 per cent silicon.

On the other hand, the carbon falls from this point (about 0.5 per cent silicon) as the silicon falls, because these irons are made in a colder hearth. The temperature of the iron as produced is not sufficient to enable it to take up its maximum carbon. The fact that at this silicon percentage occurs the maximum carbon is probably also a factor in the occurrence of spotted irons within a limited range on either side of this point.

While it has been demonstrated that high carbon leads to certain exceedingly objectionable qualities in iron, it is, nevertheless, not to be assumed that high carbon is always bad, or that the lower the carbon the better the iron, since this is far from true. The hardness of chilled iron depends largely upon its content of iron carbide. This compound contains 6.66 per cent of carbon, so that an iron with even 4 per cent of carbon is less than two-thirds carbide or cementite. The farther we fall below 4 per cent, the smaller the percentage of carbide which can be formed from the carbon present, and, other things being equal, the softer the chill

in the same proportion. In order to obtain the benefit of the high carbon, we must be able to retain the carbon in the combined condition and not have it thrown out as graphite either before or after freezing; this, you will see later, we now have a means of doing. For chilling purposes, therefore, the carbon in iron needs to be high. When the carbon falls much below 3 per cent the character of the metal seems to change. It is probably for this reason that steel scrap, with a mixture of which by good practice castings can admittedly be made strong, can only be used in a limited proportion in chilled castings, because, if used to a greater extent, it dilutes the carbon of the whole charge so much as to impair the hardness of the chilled material.

So far as the blast furnace is concerned, we do not need to concern ourselves with carbon lower than about 3.5 in any ordinary range of silicon, since as far as my knowledge goes, furnaces seldom make lower carbons than this under normal working conditions, although a furnace too cold to function properly has often been known to produce what is virtually wrought iron, which, of course, has too high a melting-point to run from the furnace and which causes endless trouble in consequence.

The lowest carbon I have ever seen was 3.03 per cent. This was a charcoal iron produced when the furnace was in trouble. Such an iron contains much oxygen-bearing material, which reacts with the carbon and causes the metal to be filled with a great mass of blowholes, so that each pig swells up to the section and general appearance of a well-made loaf of bread, and makes the material worthless for commercial purposes. This is known as "Spongy. No. 6."

The melting point of the iron-carbon alloys, as may be seen from the diagrams, Figs. 1 and 2, falls from 1500 deg. C. for pure iron to 1180 deg. C. at the eutectic point. The lowering of the melting point taking place along a straight line and being, therefore, proportional to the increase in carbon, consequently if the carbon be lowered to too great an extent, the melting point becomes so much raised as to make the metal difficult to handle in the cupola, and this rise in temperature exerts a certain very detrimental influence on high-class iron, which will be shown later.

For strength alone there seems to be no doubt that a reduction in the carbon is good, even below 3 per cent, but it is probable that only material ranging from 3 per cent to 5 per cent in carbon should be considered cast iron. The vast majority of all the iron produced lies within the comparatively narrow limits of 3.5 to 4.25 per cent.

The other elements exert an influence on the amount of carbon which iron can contain, and also on the eutectic ratio, but these influences will be better discussed, in so far as they are known, in connection with the elements concerned.

(To be continued)

Asbestos in Arizona.—Up to the present time Canada was the only locality in America where long fibered asbestos was obtained. While Wyoming produces asbestos, this material is of the serpentine type and is short fibered. Lately large deposits of the long fibered type of asbestos were discovered in Arizona, the largest deposits being in the Sierra Ancha and at Ash Creek. The asbestos of Arizona is chrysotile asbestos and is found in lime and diabase. Its nature makes it especially useful for the manufacture of fabrics. The high-grade material is at least 50 per cent of the total material mined and is the only material that is being shipped due to the high freight.

Recent Chemical and Metallurgical Patents

Iron and Steel

Blast Furnace Top.—The masonry shaft of a blast furnace is subject to considerable longitudinal movement under expansion and contraction. In order that these shall not be transmitted to the masonry lining of the top, and thus distort it, an independent top has been devised and patented by WILLIAM H. BAILEY of Gary, Ind. A diagram of this top is shown in Fig. 1.

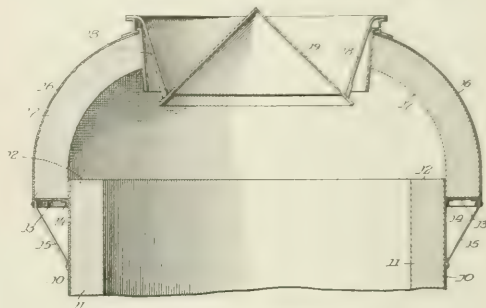


FIG. 1.—BLAST FURNACE TOP

The shell for the blast furnace shaft is shown at 10, with the lining represented by 11. This shell and lining terminates at 12. An annular plate 13 is secured to the shell 10 by means of an angle 14 and braces 15. The shell or covering 16 for the top is secured to the outer edge of the shelf 13, and is lined with masonry 17. This arrangement permits of an increase in the size of the top, and while the top is not connected to the blast furnace shaft, it is rigidly secured to the shell, without danger of being blown off, if a slip occurs. Other advantages claimed for this design are that it permits of the use of a masonry lining for the top without lessening the space within which distribution may be made, and provides ample space for the location of downcomers in the top if desired. (1,193,750, Aug. 8, 1916.)

Sintering.—A new method for sintering fines has been patented by MAX McMURRAY, BENJAMIN J. MULLEN and HARRY PEPPEL of Cleveland and Leetonia, Ohio. It consists in first forming a porous hearth on the bed of a sintering pan, about $\frac{1}{2}$ in. in depth. The material generally used is lime-stone screenings. On top of this is placed the moist or dry fines, mixed with coke-dust if necessary. The charge is then ignited similarly as in the Dwight-Lloyd sintering process and the combustion maintained by sucking air through the charge. The new feature consists in adding water to the charge continually or intermittently, as circumstances may demand, after sintering heat has been attained. The water thus added forms steam, which passes through the charge with the air. The patentees claim the following economical advantages over the common practice: it reduces the time required from 25 to 50 per cent; the product is more uniform; the exhaust apparatus may be run at a lower vacuum and finally the grate-bars have a longer life. (1,183,891, May 23, 1916.)

Sintering.—A patent has been granted to FRANK D. CARNEY and RICHARD V. MCKAY of Steelton, Pa., relating to a cover for sintering pans, the main features being its horizontal mobility on wheeled axles and its raising and lowering mechanism. The latter consists in a set of pivotally connected levers on the cover itself,

connected to the axles, permitting the raising and the lowering of the cover from a single operating position. (1,190,513, July 11, 1916.)

Gold and Silver

Method of Extracting Gold.—A process for the extraction of gold and silver especially from refractory ores, preventing formation of detrimental cyanide compounds and the conversion of the cyanide solution in part to cyanate has been patented by ALBERT W. SMITH of Cleveland, Ohio. The process consists in grinding the ore dry to about $\frac{1}{2}$ -in.; it is then further reduced by grinding in an alkaline solution of potassium cyanide and potassium bromate, using approximately 1 lb. of the former and $\frac{1}{2}$ lb. of the latter per ton of ore. After reducing to 10 mesh, the material is treated in a tube mill. The tube mill product passes to a classifier, where the 200 mesh product is floated off and the sand and coarser material returning to the tube mill. The solution containing the slimes passes to a thickener, the slimes are separated and the solution is reused in the process. The pulp from the thickener goes to agitators, where it is aerated and more cyanide, bromate and lime added if necessary. The aeration lasts from 6 to 72 hours. The pulp is then filtered and washed, the solution going to the precipitation department and the washed pulp being discarded. (1,193,197, Aug. 1, 1916.)

Electrochemical Treatment of Refractory Ores.—A patent was granted to WILLIAM HOLMAN JAMES of Johannesburg, South Africa, for the treatment of refractory ores of gold and silver prior to the cyaniding process. Essentially the process consists in electrolyzing a solution of a salt of a mineral acid, withdrawing separately from the electric circuit the portion of the solution in the vicinity of one of the electrodes, treating the ore therewith until the refractory constituents are dissolved and removing the solution containing the refractory elements. The ore then is left amenable to the ordinary cyanide process for the extraction of the values. (1,184,456, May 23.)

Copper, Lead and Zinc

Electrolytic Cell.—An apparatus for electrolyzing copper solutions has been patented by WILLIAM E. GREENAWALT of Denver, Col. The main objects in view were the more efficient application of the electric current, the retarding of the disintegration of the electrodes, keeping the electrodes free from polarizing agents and maintaining the apparatus in continuous operation for extended periods. The main features employed are: the separating of the anolyte and catholyte by means of a diaphragm, thorough agitation of the electrolyte and the addition of depolarizers and the automatic removal of anode slimes. The cell is of the horizontal type. The main chamber contains a horizontal cathode and the catholyte. Into this is placed the independent porous anode bell, so constructed, that it may be differentially oscillated by some mechanical device. The anode compartment is an independent unit and may be bodily removed from the cell. The oscillating motion serves to automatically agitate the electrolyte, to clean the anodes and to collect the anode slimes at one end of the anode chamber, permitting the easy removal of said slimes. The diaphragm also diminishes the fouling of the cathode electrolyte. The depolarizer added is usually sulphur dioxide. The automatic handling of the anode slimes and the foul electrolyte makes it possible to increase the period of operation. The following new facts have been demonstrated by the use of this new cell: First, the amount of lead perox-

idized at the anode, on using lead anodes was reduced from 1600 lb. of lead to 40 lb. per ton of copper and secondly abnormally high current densities could be employed, i.e. 104 amperes per square foot gave an efficiency of 99 per cent. (1,187,903, June 20, 1916.)

Disintegration of Anodes.—A process for preventing the disintegration of graphite electrodes in the electrolysis of solutions was granted to GEORGE D. VAN ARSDALE of New York, N. Y. It consists in adding enough depolarizing agent or agents to prevent the formation of gaseous constituents in the free state. The gases originally formed unite in the nascent state with the depolarizer under the given conditions. (1,193,741, Aug. 8, 1916.)

Zinc Condensation.—A patent was granted to HENRY SWIFT KIMBALL of St. Louis, Mo., for increasing the efficiency of zinc condensation. The essential feature is the attachment of a Cottrell collecting device in the zinc condenser. The high electrical potential precipitates the finely divided zinc in the condenser gas, thus collecting it in the metallic zinc in the condenser and reducing the amount of blue powder formed in general practice to a great extent. (1,189,830, July 4, 1916.)

Zinc Recovery.—CHARLES H. FULTON of Cleveland, Ohio, has patented a method for making briquettes, which may be used in zinc retorts for the production of zinc. The ore is crushed and calcined in the usual way and then mixed with pulverized coke and a binder such as pitch or a mixture of pitch and tar. The thoroughly mixed mass is then heated to the melting point of pitch and passed through the briquette press, where it is subjected to a pressure of 500 to 1000 lb. per square inch. The briquettes are then heated until the binding material has been coked. The heating should be done under non-oxidizing conditions. The novel feature of these briquettes is their structure, consisting essentially of a large number of ore particles embedded in a matrix of coke. The briquettes are retorted and will maintain their volume and form during the operation. (1,193,680, Aug. 8, 1916.)

Process for Manufacturing Lead Sulphate.—A method for producing neutral and basic lead sulphate in a fine state of division was patented by BERNARD S. WHITE of Joplin, Mo. Litharge is converted into a fume by blowing hot air over it while in the melted state. The fume thus formed is then mixed with sulphur dioxide gas and an excess of air. The whole is then heated to such a temperature as to insure the formation of the desired lead sulphate. (1,187,949, June 20, 1916.)

Welding

Welding Unlike Metals.—An interesting process of welding unlike metals, which is stated to be particularly applicable to uniting iron or steel with copper or copper alloys, is patented by FRED. B. COREY of Barberton, Ohio. The process is somewhat similar to soldering, except that the metals when joined cannot be separated by heating the joint above the melting point of the metal used in welding.

In joining an iron or steel bar to a hollow copper tube by this process so that the copper tube surrounds the bar, the iron or steel bar is first thoroughly cleaned and the surface then covered with an alloy of tin and lead. This coating may be applied by dipping in a bath of metal or by means of a soldering iron or by any of the well-known soldering or tinning processes, using as a flux a solution of zinc chloride or any of the commercial "soldering" acids or fluxes.

While the low-melting-point metal is still hot, the superfluous metal is wiped off, and the iron bar allowed to cool. The copper tube is then heated in a bath of potassium chloride to prevent oxidation, and the bar pressed into the tube. (The inside diameter of the tube when cold is a little less than that of the bar.) The bar and tube are then heated until the lead-tin mixture alloys with the copper, forming a tight joint. The temperature used should be as high as possible without melting the copper metal. In welding copper to steel, good results were obtained with a temperature of 900 deg. C. (1,193,667, Aug. 8, 1916.)

Nitric Acid

Oxidation of Ammonia to Nitric Acid.—Interesting developments in the production of nitric acid by the oxidation of ammonia are contained in three patents recently issued to WALTER S. LANDIS of New York City (assigned to Frank S. Washburn of Nashville, Tenn.). In passing an ammonia mixture over a catalyser to form oxides of nitrogen, the combustion takes place best at about 700 deg. C. With a mixture of 1 volume of ammonia to 15 volumes of air the resulting flame temperature is only about 460 deg. C. Thus there is a deficiency of 2670 calories per cubic meter of ammonia burned. With 1 volume of ammonia to 10 volumes of air the flame temperature is only 640 deg. C. With a 1 to 7½ mixture the right temperature would be produced, but when less than 1 to 10 is used it does not operate well. Therefore a certain amount of heat must be applied to the reaction. The present patents propose to supply this heat by passing a current through the catalyser. A special form of catalyser, as described in one patent, is used, constructed as shown in Fig. 2. A perforated receptacle 1 of re-

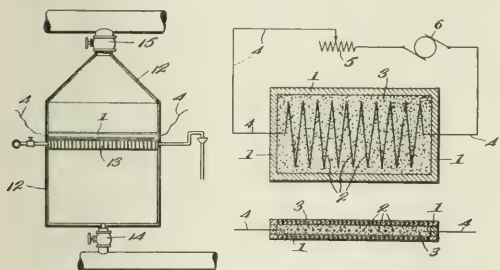


FIG. 2—PLATINUM CATALYSER

fractory material contains a resistance 2 of iridium-free platinum wire. Surrounding this resistance is a powdered catalyzing material 3, which may consist of platinized asbestos, or other non-conducting salts as plumbates, manganates, etc. In the other patent the catalyser consists of fine platinum wire wound around a frame of insulating material. This catalyser is arranged in the oxidation chamber 12, as shown. A feature of the process is the cooling of the mixture before passing it through the catalyser. Refrigerating coils may be used in addition to the cooling arrangement 13, shown. (1,193,798-799-800, Aug. 8, 1916.)

Coke Ovens

Recuperator Wall for Coke Ovens.—In order to effect greater heat economy in coke oven operation a form of recuperating wall has been patented by ARTHUR ROBERTS of Evanston, Ill. This wall is made up of blocks laid in courses, the blocks of each course breaking joints with the blocks of the adjacent courses.

Each block has a recess in the center of its side face and in its bottom face to provide a meshwork of interconnected passages on the interior of the wall. This wall is placed between the walls of two carbonizing chambers, and becomes heated by contact with the walls of the carbonizing chambers. The air to be used in burning the gases, which are passed through the walls of the carbonizing chamber, is preheated by passing it through the recuperator wall. (1,193,069, Aug. 1, 1916.)

Sodium Hypochlorite

Electrolytic Cell for Production of Bleach.—An electrolytic cell for the production of sodium-hypo chlorite in which the electrodes are built up in removable units is patented by ALBERT HOLLIDAY of Wimbledon, London, England. Two cross-sectional views of an electrode unit are shown in Figs. 3 and 4 respec-

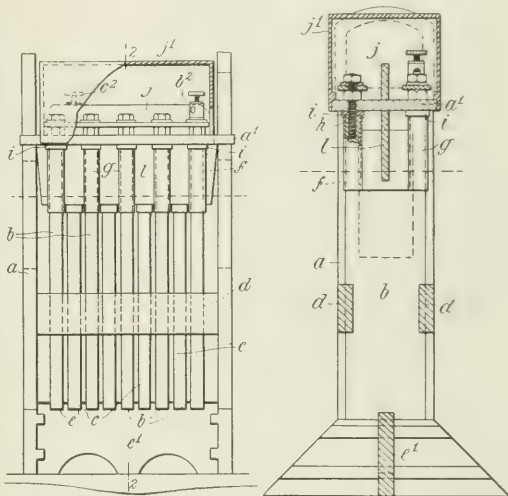


FIG. 3—SIDE ELEVATION OF ELECTRODE UNIT

FIG. 4—END ELEVATION OF ELECTRODE UNIT

tively. Fig. 3 is a side elevation and Fig. 4 is an end elevation. The unit consists of a removable frame *a* of acidproof, non-conducting material. One set of electrodes is represented at *b* and another set at *c* (Fig. 3). These are arranged close together, that is, about ½ in. apart, and a heavy current density is used. The electrodes are connected in sets by lugs *f* and metal studs *h* to common busbars, each with a common terminal *b'* and *c'*. Each set of electrodes may be used either as anodes or cathodes. This feature is of advantage when the cathodes become coated, as by reversing the current the deposit may be dislodged. The connecting lugs *f* are coated with acidproof solution and inclosed in a sheath *g* of acidproof non-conducting material. A rubber washer *i* is used between the upper ends of the lugs and the top plate *a'* of the frame to insure a liquid tight joint. An insulating partition *j* is provided between the two busbars, and over this and the busbars and terminals is fitted a cover *j'* adopted to prevent any corrosion of these parts from the chlorine. It is claimed that absorption of chlorine by the caustic soda solution formed is facilitated owing to the distance of the upper edge of the electrodes below the surface level of the liquor and by the sheathing of the lugs. (1,193,786, Aug. 8, 1916.)

Synopsis of Recent Chemical and Metallurgical Literature

Colloidal Chemistry

Selective Adsorption and Differential Diffusion.—

An interesting contribution to the symposium on "colloids," held at the New York meeting of the American Chemical Society, was presented by JEROME ALEXANDER. He states that substances in solution diffuse at different rates through finely divided or colloidal structures, and may thus be more or less completely separated from each other by differential diffusion. This effect is accentuated when one or more of the substances is selectively adsorbed by the structure through which the diffusion takes place. These facts are illustrated by tubes showing the separation, into its components, of ferric chlorid upon diffusion through a sensitized agar gel, and also by the separation of mixtures of dyes upon diffusion through blotting paper.

"The action of selective adsorption and differential diffusion in effecting secretion and excretion must be at once manifest. Easily hydrolyzable compounds may be thus split up in the body, and yield secretions of acid nature like the gastric juice, or of alkaline nature like the pancreatic juice, depending upon the structure of the organ, the location of its cavity and of its afferent and efferent vessels. Individual compounds in the blood stream or other body juices may also be selectively diffused out, concentrated, or separated from other accompanying substances. By selective adsorption, circulating substances may be fixed and taken from the circulation; in fact, poisons are usually taken up selectively by certain organs or tissues. . . ."

"In plants, differential diffusion and selective adsorption seem to be intimately bound up with growth and the circulation of the sap. The plant tissues are mainly colloidal gels or finely integrated structures, and as the sap circulates or diffuses through them, each tissue selectively adsorbs and elaborates certain particular constituents. Thus, with the potato and tapioca plant, the starch-forming substances are fixed in the roots; with the sago palm they are fixed in the stem pith, and with cereal grains, in the seeds. As long as the adsorptive tissues are unsaturated or are multiplied, so long can growth continue. . . ."

"Adsorption and diffusion are phenomena that lie in the colloidal zone, which imperceptibly blends into the physical on one hand and into the chemical on the other. The dimensions involved approximate the so-called radius of molecular attraction so that the forces of surface tension, capillarity, electric charge, colloidal protection and the like are all influenced by chemical forces. Indeed, before substances can unite chemically, their particles must be brought first into proper subdivision and proximity by solution, fusion, ionization, or even by mere pressure, as has been demonstrated by W. Spring, who caused fine dry powders to combine by high pressure.

"If the degree of subdivision is not profound enough to permit of the combination of isolated atoms or ions with each other, chemical combination in the strict sense may not occur, but there may be produced "adsorption compounds" resulting from the union of atomic or ionic mobs in indefinite or non-stoichiometric proportions, under the influence of more or less modified chemical forces.

"On the other hand, if the degree of subdivision proceeds far enough, real chemical reactions may occur and be rendered irreversible by the diffusion or adsorption of one or more of the products into a surrounding colloidal sol or gel. When we consider the

great variety of bio-colloids and their susceptibility to changes of structure and diffusive or adsorptive capacity, we can easily understand the almost infinite number of reactions that may go on within their recesses, as they swing the balance of the law of mass action over particles reduced to a reactive degree of subdivision. And we must not be surprised to see technical processes develop upon the basis of these principles."

Emulsions and Suspensions With Molten Metals.—

At the New York meeting of the American Chemical Society, a paper was presented on this subject by H. W. GILLET, of which the following is a short abstract:

The difficulty of getting aluminium chips and "blue powder" to coalesce in melting is due to the envelopment of the globules by a skin or oxide or other impurities, and to get coalescence the disperse phase of the "emulsion" must be reversed. Enclosures of slag, dross or gas bubbles in castings may be looked upon as due to an emulsion or suspension in the molten metal. While such emulsions are generally undesirable, uniform emulsions in metals may possibly have valuable properties. Hence the colloid chemist should extend his field of work and show the metallurgist and foundry man how to break up, how to make and preserve such emulsion.

Paints.—In discussing paints at the colloid symposium of the American Chemical Society, T. R. BRIGGS said the properties of pigments are influenced fundamentally by the degree of subdivision of the particles. For the special case of a mixture of two pigments of different colors, the tinting power of one pigment in the mixture is dependent chiefly upon the relative size of the particles. If one pigment is relatively fine and the other coarse, and if the finer particles coat over the surface of the coarser ones, the color of the mixture is the color of the finely ground pigment. The theory leads to an understanding of the use of inert pigments as diluents.

Vulcanization of Rubber.—The various theories expounded to account for the phenomena of rubber vulcanization were discussed in a paper presented by D. SPENCE at the New York meeting of the American Chemical Society. The paper was presented at the colloid symposium. The author outlined four different theories which include all the attempted explanations of vulcanization. These are: 1, Chemical reaction; 2, Adsorption; 3, Polymerization; 4, Rubber and rubber derivatives. The theory of an actual chemical reaction taking place between the sulphur and the rubber was long held by many to be the explanation of vulcanization. Experimental data are, however, more in accord with adsorption than with a chemical reaction theory. The polymerization theory that the sulphur causes an increase in the number of atoms in the rubber molecule is giving way to a later and more plausible theory proposed by a Russian chemist, viz., that a rubber derivative is formed when sulphur is added to rubber, and this rubber derivative is adsorbed by the balance of the rubber. He has made extensive experiments and the theory so far seems to hold. According to this theory vulcanization is a compromise between chemical reaction and adsorption.

Plaster of Paris.—A paper on this subject of which L. A. KEANE was the author was presented at the New York meeting of the American Chemical Society. The paper was read by Dr. W. D. Bancroft. He said that in making investigations on plaster of Paris he found that, according to the literature, they heated gypsum to 200 deg., or a little higher in this country to make plaster of Paris, whereas in Germany they heated

to a much lower temperature, approximately 130 deg. The reason for this was not evident until investigations showed that the time factor affected the end product, and whereas in Germany they heated to a relatively lower temperature for a longer time, in this country they heated to a higher temperature for a shorter time, giving approximately the same amount of dehydration of the gypsum. The question of wetting was then investigated to determine why some plasters would set and others would not. The investigations showed that it was simply a question of fine grinding and that dead-burned gypsum, which ordinarily will not set, will set if ground fine enough. The setting property depends on relative size and not on different chemical modifications of the material.

Potash

The Potash Situation.—In an American Chemical Society paper presented at the New York meeting, H. A. HUSTON said that no potash had been received from Germany this year, though some has been received from other countries. A few minor waste materials, which have always been sources of potash, such as tobacco stems, wood ashes, etc., have been better utilized than heretofore. About 45 tons of K₂O per day are being produced from new sources, which is about 6 per cent of our normal requirements. Of the sources yielding this, viz., kelp, cement, alunite and Nebraska Lake, the last was responsible for more than half the total output. He said the potash mines in Germany were not full of water as reported, but were operating regularly at nearly normal capacity.

Viscosity

Measuring Viscosity of Very Viscous Substances, such as Heavy Oils, Petroleums, Asphalts, Resins, etc.—Bureau of Mines Technical Paper 157, "A Method for Measuring the Viscosity of Blast-Furnace Slags at High Temperatures," contains a description of the new Feild high-temperature viscosimeter by which the viscosity of slags can be accurately measured up to temperatures as high as 1600 deg. C. This viscosimeter gives results which can be expressed in terms of specific viscosity, referred to that of water, or in terms of absolute C. G. S. units. A single run with the apparatus furnishes a temperature-viscosity curve over the entire temperature range desired. The principle employed depends upon the familiar law that, given two concentric cylinders—the space between being filled with the viscous liquid under examination—a torque proportional to the viscosity of the liquid is exerted upon the inner cylinder when the outer cylinder is rotated at a constant angular velocity. In the Bureau of Mines method this torque is measured accurately by suspending the inner cylinder by means of a calibrated steel or phosphor bronze suspension, and at the same time, weighting and damping the suspended system so that in its motion about its axis of rotation obeys laws similar to those governing the motion of a damped D'Arsonval galvanometer. The principle is not new, but one which has been strangely neglected and not hitherto used at elevated temperatures. Unlike the familiar Stormer viscosimeter, this new apparatus is entirely free from friction, measurements being made when the suspended system is in static equilibrium. Also, the liquid under observation is not deformed at any time, but is simply subjected to a uniform shear. Deflections may be read with extreme accuracy by means of a mirror and galvanometer scale, but for many practical purposes a pointer and graduated arc are sufficiently precise.

The method is applicable to substances possessing the most varied degree of viscosity, and, on account of the

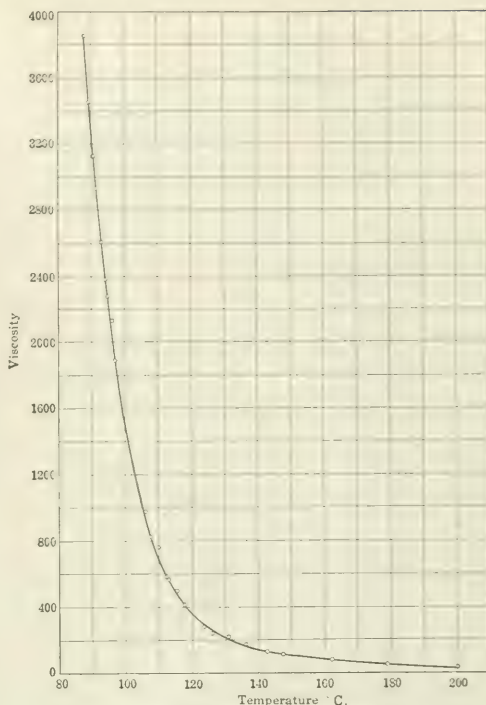


FIG. 1—TEMPERATURE-VISCOSITY CURVE OF AN ASPHALT PRODUCT

difficulty which has been hitherto encountered in estimating even approximately the viscosity of very viscous substances which do not permit of a ready passage through a capillary, finds a very fortunate application in the measurement of the viscosity of such materials as asphalt, pitch, heavy oils and petroleums, varnishes, polymerized organic products, resins, emulsions, colloidal substances, glues, greases, lards, vaselines, pasty mixers, paints, lubricants, and clay slips.

A well-known plate glass company evinced an early interest in the application of the high-temperature model of the Feild viscosimeter to the measurement of the viscosity of molten glass at high temperatures, and is taking steps to make use of the method in a technical way. The method is as readily applicable to the measurement of the viscosity of glass as that of blast-furnace slags. In fact the latter require a much higher operating temperature than do most glasses, and for this reason measurements on glasses are capable of more accurate temperature control and temperature measurement.

Fig. 1 shows the results of viscosity measurements made on a sample of a new type of asphalt, furnished by Dr. W. A. Hamor of the Mellon Institute for Industrial Research. Viscosity values are referred to the viscosity of water at 20 deg. C. as unity. These units are therefore equal to 1/100 C. G. S. unit. The apparatus was calibrated, not against water, but against a more viscous liquid of known viscosity, e.g., castor oil, although glycerine, rape-seed oil, or liquid petrolatum might be used equally as well. The temperature-viscosity curve of this asphalt is seen to be a smooth one, with a maximum change of curvature in the neighborhood of 120 deg. C. (248 deg. Fahr.).

Chemical Control in the Manufacture of Enameled Ware

Although the Elyria Enameled Products Co. has maintained a chemical laboratory for more than five years, it has more recently realized the necessity for better facilities than were afforded under the early conditions. The contract for the new laboratory was let with Henry Shenk & Co. of Erie, Pa., about May 1, 1916, and the building has been in use since Sept. 1. It has brought forth so many favorable comments from the friends of the company that it seems worth while to give a brief description, together with an outline of the work carried on.

The new laboratory is located at the south end of the property owned by the company and faces on Taylor Street. It is of hollow-tile construction, 27 ft. by 30 ft., one story. It contains an office, balance and instrument room, and analytical laboratory. The latter is approximately 27 ft. by 18 ft. and is equipped with two 6-ft. hoods and 50 linear feet of table space.

In addition to the above building there is an experimental furnace room in connection with the factory proper, which, although not an actual part of the laboratory, is entirely given over to experimental and research work.

The accompanying illustration shows the exterior of the laboratory with the main office and a portion of the factory in the back-ground. The work which is carried on by this laboratory comes in general under two heads: first, operations which have to do with the manufacture and investigation of enamel, and secondly, the consideration of the wishes of the customers as related to enamel-lined products.

Under the first line of work come factory control and enamel development. The former involves the analysis of the steel and the various enamel raw materials, together with routine tests, both mechanical and chemical in nature, assuring a uniform product.

Research work is continually in progress, leading to the improvement of present formulæ and the development of new ones. Experimental batches are mixed, smelted, ground and burned on small trial dishes. Various tests of the physical and chemical properties of enamels are made and considerable work is done in the study of enamels under the microscope.

The relation of the laboratory to the trade has to do with the choice of proper formulæ to meet various conditions and the determination of the best methods of handling various kinds of material in enamel-lined

equipment. The customer is urged to furnish either a detailed statement of chemical conditions to which the enamel is to be exposed or samples of materials to be handled. The laboratory then proceeds to determine which enamel is best suited to the needs of the customers, and in cases where enamel-lined equipment will not be serviceable, reports to that effect.

Further than this, there are many problems arising relative to the proper handling of material. Various tests are run either on an experimental or a larger scale, involving the heating, cooling, condensation and agitation of various substances under consideration.

A New Automatic Oxygen Carbon Monoxide and Carbon Dioxide Recorder

In a large number of industrial plants urgent need has been felt for a recording instrument showing graphically and continuously the percentage of oxygen. Such a machine is illustrated and described below. It has been in actual use for some time and should be of interest to all plants that have limestone furnaces, cement kilns, etc., and to the oxygen manufacturing industry. It will immediately show the percentage of purity of oxygen, as well as any irregularities in charging the cylinders and thus prevent such accidents as have occurred recently in Chicago and San Francisco.

For this special purpose an instrument known as the "Mono" purity recorder has recently been placed in the market. This is graduated from 80 to 100 per cent and each per cent is of such wide range as to make fractions very clearly readable.

Fig. 1 is a general view of the recorder which in reality is a combination CO₂ and O recorder and may be used for either gas.

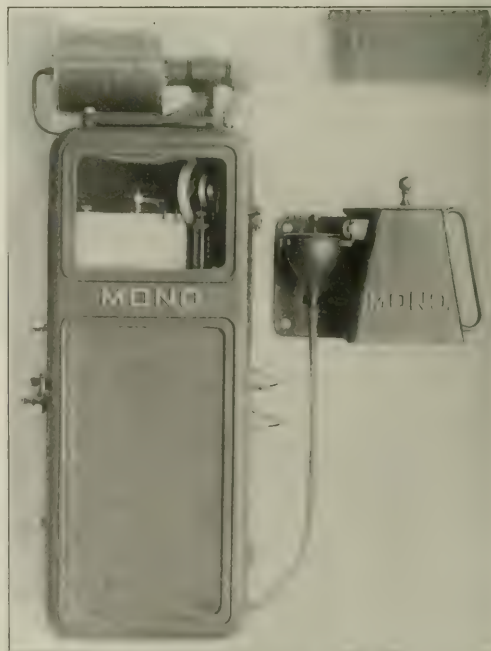


FIG. 1—GENERAL VIEW OF RECORDER



LABORATORY AT THE ELYRIA ENAMELED PRODUCTS CO.

Fig. 2 is an interior view of the recorder. Except for the electric oven on top, the machine is a CO₂ recorder. Within the case, slightly to the right of the center line of the instrument, a valve will be noted, marked 1 and 2. With the valve in position 1 the gas will pass through a solution of KOH, thus absorbing CO₂ and switching off the electric oven. Position 2 allows the gas to pass through the electric oven, automatically started up and by-passing the vessel containing KOH. In this latter position of the valve the instrument acts as an oxygen recorder, while in the former position of the valve the instrument acts as a CO₂ recorder. A separate appurtenance is furnished to make the instrument record the percentage of monoxide.

In order to make the operation of the instrument clear it will be necessary to describe the working of the CO₂ recorder first as this is the basis upon which the instrument is built.

The absorption-apparatus is mounted in the lower part of the cast-iron cabinet, to which it is fastened by means of three screws in the bottom. The pressure-medium (water or air) by which the apparatus is driven passes through the regulating valve 1 (Fig. 3 and 4) and the pipe 2 into flask 3, which contains mercury. This is thus pressed up into the pipes, 4, 5, 6 and 8.

Pipe 4 is at the top connected with the burette in which the volume of the gas is ascertained. Pipe 5 is in communication with the outside air and the upper part of pipe 6 passes into an expansion of pipe 8 (Fig. 3) and 5 (Fig. 4).

The lower part of pipe 6 passes into the bottom of a recipient 2 and is thus only indirectly in connection with the mercury in flask 3. The position of this inner recipient 2 in flask 3 is such that the mercury in pipe 6 will always rise higher than that in pipe 5 or 8 (Fig. 3).

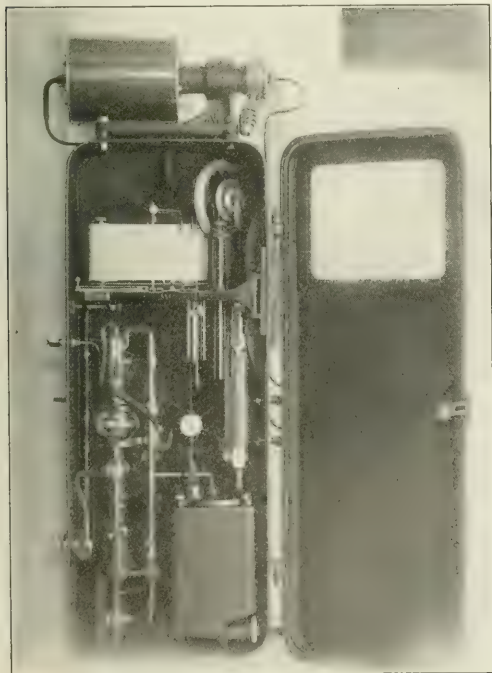


FIG. 2—VIEW SHOWING INTERIOR OF RECORDER

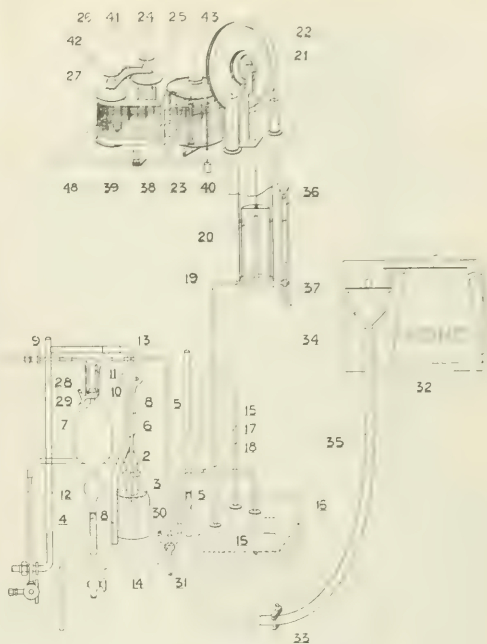


FIG. 3—DIAGRAM OF APPARATUS

As the pressure is increased, the mercury is finally forced out of the recipient 2 through pipe 6 and runs down into pipe 8 (Fig. 3) or pipe 5 (Fig. 4). As soon as pipe 6 is empty of mercury, the pressure-medium comes in contact with the outside air, and the excess pressure in flask 3 disappears. The mercury in pipes 4 and 5 then runs back into flask 3 filling it until some of it finally runs into the recipient 2. By this means the lower outlet of pipe 6 is closed. The pressure-medium is now no longer in contact with the outside air and the pressure rises again in flask 3 and the process above described is repeated. In this way an alternately rising and falling movement of the mercury is brought about, which movement is utilized in the following manner:

When the mercury sinks as above described, the gas to be analyzed is drawn in from the chimney through the filter and the tubing to the absorption-apparatus. Through the coupling 9, the mercury seal 10 and the pipe 11, this gas then passes into the burette 7, where it is measured, the pressure and temperature always being constant. When the mercury rises, the gas from the burette is pressed through pipe 13, the mercury seal 14 and pipe 15 into the recipient 16, which is filled with absorption-liquid. The carbonic or sulphuric acid in the gas is here absorbed, the remainder of the gas being pressed through pipe 18 up into the gasometer 20, which is shut off from the outside air by water.

When the gas enters, the gasometer rises and turns the wheel 21 which in its turn finally acts on the wheel 22. On this wheel and connected with it by means of a metal chain hangs the pen 23, which draws the curve on the diagram-paper 24. The lower extremity of the line produced indicates the percentage of gas absorbed.

When gas is drawn into the burette, pipe 17 comes in contact with the outside air, the gasometer then sinks back to its original position and the apparatus makes a new analysis and a new registration.

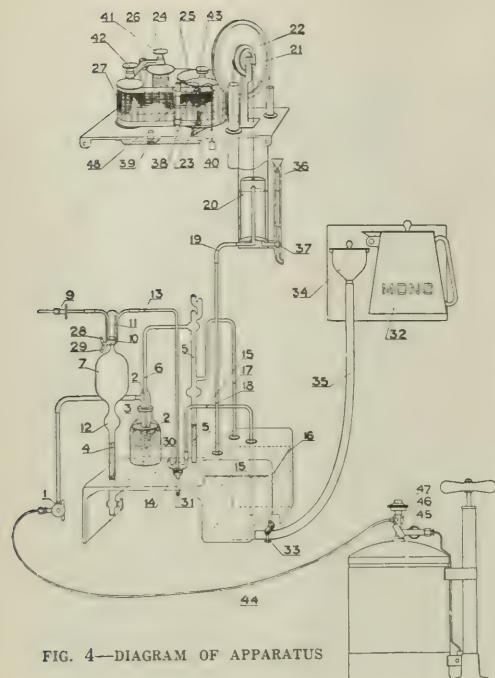


FIG. 4—DIAGRAM OF APPARATUS

The diagram is drawn from the roller 26 over the drum 25 by means of a clock in the latter, being afterwards automatically rolled up on the roller 27, or, at will, simply cut off.

In this manner the instrument will show either percentages of CO_2 , oxygen, or if desired CO on the same chart of very wide range. Up to 60 analyses can be made per hour with great accuracy.

The apparatus is being introduced into this country by F. D. Harger of 21 Park Row, New York City.

Barite in Northern Ontario.

—The world's largest barite deposit is situated in Langmuir Township on Night Hawk Lake, Northern Ontario, and is owned by the Premier Langmuir Mining Company. The deposit is estimated at 50,000 tons of the finest quality of barite and contains some silver. The occurrence of these two minerals simultaneously is a very rare one.

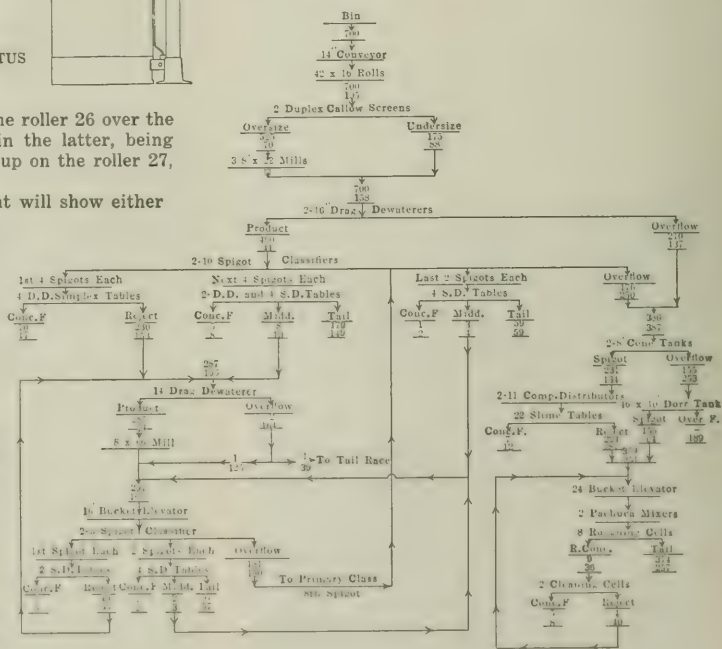
Barite is generally used in the manufacture of Scotch linoleums, white paint and hydrogen peroxide. As soon as it is possible to get the machinery on the ground a mill of from 30 to 50 tons' capacity will be erected. This mill requires special machinery.

Flow Sheet of Miami Mill

To supplement the report of the Arizona meeting of the American Institute of Mining Engineers in our last issue, we give on the bottom of this page the flow sheet of the Miami mill which was mentioned on page 492.

The dry tons milled from January to June, 1916, were 859,485, or 4722 tons per day. The copper in the feed averaged 2.09 per cent, of which 0.32 per cent was oxidized and 1.77 per cent was present as sulphide. The percentage of copper in the concentrates was 41.74. The total copper in the tailings amounted to 0.56 per cent, of which 0.30 per cent was oxidized and 0.26 per cent was present as sulphide. The recovery of copper was 74.06 per cent.

Philadelphia Studying Metric System.—The Philadelphia Bourse is conducting an investigation into the extent to which the manufacturers and commission merchants of Philadelphia must use the metric system in foreign business. An attempt is also being made to ascertain their attitude toward the national adoption of the metric system. Early results indicate that progressive concerns favor the metric system and officials of such companies as the J. G. Brill Co., Midvale Steel Co., Schuylkill Forge Co. and Tindel-Morris Co. have expressed themselves in favor of it.



Notes — Upper Figures are Tons Solids in 24 Hours.

Lower Figures are Gallons Water per Minute.

A 1' Cons. F. are Feinest to Bin. Total Concentrate 30 Tons in 24 Hours.

Carrying 100 Gallons Water per Minute.

All Tail' are Feinest to Reformed Water Plant — Total Tailing 670

Tons in 24 Hours Carrying 500 Gallons Water per Minute Including

Dorr Tank Overflow and a Portion of 14 Drag Overflow.

Personal

Mr. James L. Bruce, general manager of the Butte & Superior Mining Co., is on a trip through Tennessee, Missouri, Wisconsin and Illinois, inspecting the mines and smelters of the American Zinc, Lead & Smelting Co., in connection with the proposed merger of these companies.

Mr. Ernest Child has terminated his association with Elmer & Amend to join the firm of H. Reeve Angel & Co., Inc., New York City, as their president and general manager. Business friends of Mr. Child will be interested to know that among the activities of his new association is the sole representation on this continent of the manufacturers of the Whatman filter papers.

Mr. Noel Cunningham, metallurgical engineer, has moved his offices from 200 Fifth Avenue, to 90 West Street, New York City.

Mr. F. N. Flynn, for the past seven years connected with The Arizona Copper Company, Ltd., at Clifton, Ariz., has resigned his position as superintendent of the smelting department, effective Oct. 31. Mr. Roger H. Hatchett, who has been Mr. Flynn's assistant for six years past, has been appointed acting superintendent of the smelting department. Mr. Flynn will sail from New York early in November for Chuquicamata, Chile, where he will enter the employ of the Chile Exploration Company.

Mr. Ernest G. Jarvis has resigned his position as metallurgist with the Canadian Inspection and Testing Laboratories, to take a position as chief chemist and metallurgist with the McNab & Harlin Manufacturing Co., Paterson, N. J.

Mr. E. W. Kerr is to give up his professorship in mechanical engineering at Louisiana State University to take up commercial work with the Cuba Cane Sugar Corporation, Havana, Cuba.

Mr. M. G. Kopf, formerly chief engineer for the McCormick Laboratories at Dayton, Ohio, has opened a consulting engineering office at 602 Chemical Building, Chicago. Mr. Kopf has organized a staff which, in addition to regular consulting engineering work, will render a unique service in the chemical, electrical and mechanical patent fields. This service will differ from the ordinary patent service in that it will be based primarily on scientific engineering and manufacturing knowledge, combined with legal advice, rather than primarily on legal ability. Mr. Kopf has been chief engineer of the technical laboratories of the Automatic Electric Company and electrical engineer for the National Cash Register Company.

Mr. F. E. Marcy, inventor of the Marcy ball mill, has established offices in the Atlas Building at Salt Lake City, Utah.

Mr. E. P. Mathewson, general manager of the Washoe smelter of the Anaconda Copper Mining Co., has resigned, having accepted the position of general manager for the British-American Nickel Corporation.

Mr. R. Lewis Morris, vice-president of Herman & Herman, Inc., has sailed for England to open offices there for the corporation. Offices have already been established in Petrograd, Moscow, Genoa and Barcelona, and others will be opened in the Far East.

Dr. Charles L. Parsons, of the U. S. Bureau of Mines, and secretary of the American Chemical Society, has sailed for Europe to make a study of processes of extracting nitrogen from the air as successfully used in Norway. Visits will also be made to England, France, Sweden and Italy. The study is to be made as a preliminary step to the establishment

of the \$20,000,000 Government nitrate plant in this country.

Mr. Thos. B. Stearns of Stearns-Roger Manufacturing Co., Denver, Col., is touring the West on a business trip.

Mr. Charles E. Van Barneveld visited at Salt Lake City recently.

Mr. E. R. Weidlein has been appointed associate director of the Mellon Institute of Industrial Research at Pittsburgh. He has held an industrial fellowship since 1910 and has been in charge of hydrometallurgical investigations.

Mr. G. A. White, formerly metallurgist of the American Sheet & Tin Plate Company, is now associated with the Titanium Alloy Manufacturing Company of Niagara Falls, in the same capacity. Prior to his connection with the American Sheet & Tin Plate Company, Mr. White was for a considerable time with the Rock Island Railroad and also with the Eastern Steel Company, Pottsville, Pa., where he was engaged in the manufacture of structural material.

Book Reviews

The Flotation Process. By Herbert A. Megraw. Octavo (12 x 23 cm.), 249 pages, 48 illus. Price, \$2.50. New York and London: McGraw-Hill Book Company, Inc.

A timely and welcome sketch for the use of anyone interested in any way in ore dressing; this little book describes fully and accurately the rise, scientific principles and mill practice of this process. Admitting that the principles involved are being actively discussed, and that litigation is hampering the development of the process, yet frequent reports will be necessary to keep pace with its rapid progress, and the author must make a flash-light picture of the state at the date of his writing. This Mr. Megraw has done quite acceptably.

Practical Physical Chemistry. By J. B. Firth, M.Sc. Duodecimo (12 x 17.5 cm.), 178 pages, 74 diagrams. Price, \$1.00 net. New York: D. Van Nostrand Company.

This is a well-planned guide to student laboratory practice, animated by the thought that "one principle demonstrated by the student himself is of far more value to the student than pages of lecture notes." The sections cover thermostats, densities of gases, liquids and vapors, viscosity and surface tension, solubility, molecular weights, transition points, osmotic pressure, refractivity, rotary polarization, spectrum analysis, partition coefficients, thermochemical measurements, transport numbers, electrical conductivity, electromotive force, velocity of chemical reaction, quantitative electrolysis, electrolytic formation of salts, preparation of colloids.

The Heat Treatment of Tool Steel. By Harry Brearley. Second edition, octavo (12 x 22 cm.), 223 pages, 110 illustrations. Price, \$3.50 net. London and New York: Longmans, Green & Co.

A good book made better—a fine example of a particular topic handled by an expert, who knows what he knows and "sticks to his last." His experience is Sheffield experience, to which is added the refinements of the modern science of steel. Every maker and user of tool steel needs all the information there is in this book. It comes short of completeness in one or two directions, such as the handling of the rarer alloy tool steels, e.g. molybdenum steels, but this is apparently because the author's experience did not extend to them. Plate paper is used throughout, bringing out the photomicrographs beautifully.

INDUSTRIAL

Financial and Construction News

Financial

The American Truss & Supply Company, Inc., has filed papers of incorporation at Albany, N. Y. The directors are J. Fisher, J. C. Gallup and S. C. Clark. The company is capitalized at \$20,000 and will deal in drugs and chemicals, trusses and supplies.

The Baumann Dyestuff & Chemical Company, Inc., Brooklyn, N. Y., has been incorporated with a capital of \$15,000. The incorporators are J. S. Mulrone, G. A. Raftery and E. F. McGee.

The Bison Gas Corporation, Buffalo, N. Y., has been incorporated to produce petroleum, natural gas, by-products. The capital is \$25,000, and the incorporators are W. W. Sears, S. B. Nye and W. J. Brannen.

The Daniel Boone Oil Company has been incorporated to acquire lands containing oil, petroleum, gas, coal and other minerals, and develop same, and to refine and prepare oil for market. The capital stock is \$2,500,000. The incorporators are M. L. Rogers, L. A. Irwin and Harry W. Davis, of Wilmington, Del.

The Bristol Chemical Works, Bristol, Tenn., has been organized with a capital of \$50,000, and has begun work on a new plant, machinery for which has been ordered.

California Fertilizer Works has filed articles of incorporation at Fresno, Cal. The headquarters of the company are in San Francisco and the capital is \$100,000. Stockholders and directors are John Boyle, John Lacoste, Jacques Bareilles, E. O. Rieser and C. A. Artigues, all of San Francisco.

The Calkins Chemical Company, Pueblo County, Cal., has been incorporated with a capital of \$25,000. The incorporators are W. H. Warner, W. L. Hartmann and Z. H. Nelson.

The Clinton Oil & Manufacturing Company, Clinton, S. C., has been purchased by a stock company for \$30,000, and business will be conducted under the name of the Clinton Oil Mill.

The Commonwealth Chemical Corporation, 1500 Garden Street, Hoboken, N. J., has been incorporated to make and sell dyes, chemicals, drugs, paints and oils. The capital stock is \$25,000. The incorporators are Fritz G. Stockelbach, Edward A. Walsh and Carl Schelzka.

The Connecticut Brass Corporation, with \$2,000,000 capital, has been incorporated to carry on the business of brass manufacture. The incorporators are Herbert E. Latter, Norman F. Coffin and Clement M. Egner, of Wilmington, Del.

The Consolidated Rolling Mills & Foundries Company, Inc., is a new incorporation formed with a capital of \$1,000,000 to deal in merchandise of all kinds. Herbert E. Latter, Norman F. Coffin and Clement M. Egner, of Wilmington Del., are the incorporators.

The Du Pont Powder Company and the Ana Explosives Company have announced that they will convert their explosives factories into factories for manufacturing intermediates and dyestuffs when the demand for explosives becomes normal. The change to making intermediates would not involve a great deal of expense, as much of the same apparatus is used. Just what will be done as to finished dyes is not known.

The Electric Steel Company, St. Paul, Minn., has recently been organized with a capital of \$300,000, and plans building a factory in St. Paul. The incorporators are G. W. Harrison, Max Toltz, J. H. Dalton, J. C. Pettibone, E. F. Hamilton, Louis Taper and C. C. Haupt.

The Epac Company has been incorporated at Dover, Del., with a capital of \$1,200,000. The company will manufacture and sell medical preparations. The incorporators are M. C. Lewis, L. E. Irwin and Harry W. Davis, all of Wilmington.

The Filler Fibre Company, Detroit, Mich., has been organized with a capital of \$200,000, and plans the erection of a pulp plant at Muskegon, Mich. H. G. R. is president.

The Gilmore Fire Clay Company has been incorporated at Pittsburgh by A. L. Gill, C. A. Burnser and D. E. Mitchell.

The Hoffman Oil & Refining Corporation has filed articles of incorporation at Dover, Del. The company has a capitalization of

\$10,000,000 and was formed to acquire and develop oil lands and build oil tanks. The incorporators are Ferris Giles, L. S. Dorsey and K. M. Dougherty, all of Wilmington.

The Homes Oil Refining & Gas Company, capitalized at \$250,000, has filed articles of incorporation in Utah. The company plans the development of oil and gas resources along the shores of the Great Salt Lake. The officers are Edwin L. Smith, president; Levi M. Harmon, secretary; treasurer: H. L. Nelson, H. A. Langford, H. W. Horn, John T. Neff and John J. Van Allen, directors.

The Industrial Oil Company, Inc., Syracuse, N. Y., has been incorporated in New York State to deal in oil products. The capital is \$5,000, and incorporators are H. D. Brockett, E. H. Goodrich and H. T. Butler.

The Ion Dyes Company, Wilmington, Del., has been incorporated to manufacture, sell and deal in and with chemicals, dyes, etc. The capital is \$150,000. The incorporators are Herbert E. Latter, Norman F. Coffin and Clement M. Egner.

The Jap-Ammonia Company of Rochester, has filed a notice at Albany of an increase in stock from \$40,000 to \$100,000.

The Joy Products Company, Inc., 68 William Street, New York, has been incorporated to deal in washing powders and chemicals. The capital is \$10,000 and the incorporators are B. E. and E. A. McAlpin, and F. E. Robinson.

Kiesel-Miner-Morse Inc., is the name of a new company which has been organized at Erie, Pa. The incorporators are Henry Kugel, Pierre A. Miner and Henry L. Morse, of Erie, Pa. The company will deal in iron, steel and other metals, shop and mill supplies, tools and machinery.

The O. C. F. Leddin Company, of New York City, has been organized with a capital of \$10,000 to manufacture chemicals. O. C. F. Leddin and Max Voetter, of Brooklyn, are directors.

The David Lupton's Sons Company, a Pennsylvania Corporation manufacturing iron and steel, has been authorized to transport business in Indiana. Philip W. Frey, Evansville, Ind., is agent. Part of the company's capital is represented in Indiana.

The J. D. McQuade Chemical Company, 75 Montgomery Street, Jersey City, N. J., is a company which will make and sell chemical products and will take over the business formerly conducted by the Phenol Products Company. The capital stock is \$125,000. The incorporators are J. D. McQuade, James J. Higgins and Thomas E. Egan, Jr.

The Mansfield Foundry Company, Mansfield, Mass., has been incorporated with a capital of \$15,000. The directors are J. M. Bullard, president; Arthur B. Colvin, treasurer, and P. D. Dean.

The Marine Engineering Corporation has been incorporated to manufacture, operate, sell and deal in and with steel, iron, machinery, tools, etc., to construct boats, barges, and all kinds of marine constructions of all kinds. The capital is \$100,000. The incorporators are Joseph N. Folwell, of Edgewater, N. J.; Matthew J. Wheeler and Hugh S. Hemingway, of New York.

The Marine Engineering Corporation Company, New York, has been incorporated with a capital of \$100,000. The incorporators are D. Graef, M. and E. Marks.

The G. H. Mead Company, paper manufacturers, of Cincinnati, Ohio, has increased its capital from \$50,000 to \$100,000 to meet increased trade.

The Metallic Chemical Company, Utica, N. Y., has been incorporated with a capital of \$100,000. The directors are William E. Higin, Alfred M. Thomsen and Arthur J. Foley, of Utica.

The Mount Holly Paper Mills, Inc., has been incorporated under the laws of Massachusetts with a capital of \$250,000. This company will operate the Mount Holly Paper Mills at Mount Holy Springs, Pa., which has been idle for six years.

The New York Color & Chemical Company, Inc., 210 West 107th Street, New York, capital \$100,000, has been incorporated to deal in chemicals, dyes and paints. The incorporators are T. F. Kelly, L. W. Nelson and J. C. Donavin.

The Nitro-Tungsten Lamp Company, Providence, has been incorporated with a capital stock of \$50,000. The incorporators

are William L. Studley, John E. Canning and Henry C. Hart, of Providence.

The North East Foundry & Machine Company, North East, Pa., has been incorporated at Pittsburgh with a capital of \$25,000. The incorporators are Edmund A. Finerty and Frank G. Pottmeyer, of North East; William W. May, of Midland, and John J. Finerty, of Buffalo.

The Oil Refiners Direct Service Company, Inc., 128 Maiden Lane, New York City, has been incorporated to deal in extracting oils, greases, acids, paints, varnishes and engineers' supplies. The capital is \$10,000 and the incorporators are G. F. Francis, I. M. Reynolds and J. H. Weinberg.

The Oriana Fertilizer Company, Norfolk, Va., is a new corporation. The capital is \$50,000. J. W. Callis is president.

The Palma Sugar Company, of Greenwich, Conn., has increased its capital stock from \$1,400,000 to \$2,960,000.

The Palmiroto Sugar Company has been incorporated in New York and Wilmington capitalists.

The Philadelphia Dyeing & Finishing Company, Inc., has been incorporated under the laws of New York State to dye, color and otherwise treat goods and fabrics. The capital is \$100,000 and the incorporators are A. W. Hardwick, W. J. Gibbons, Jr., F. Merz. The office is at 257 Fourth Avenue, New York City.

The Pittsburgh Utah Potash Company has been incorporated to engage in the business of mining and manufacturing potash, aluminum, gold, silver, copper and other metals. The capital stock is \$250,000. The incorporators are F. D. Buck, M. L. Horthy and M. E. Noblit, of Wilmington, Del.

The Satterfield Barytes Company, Cartersville, Ga., has been organized with a capital stock of \$10,000.

The S. P. M. L. Manufacturing Company, Inc., 64 Franklin, has been incorporated in New York, has been incorporated to manufacture machinery, specialties, novelties, chemicals and compounds. The capital is \$10,000. The incorporators are E. Taylor, W. W. Harton and P. H. Seman.

The O. G. Schmid Chemical Company, of Jackson, Mich., has increased its capital from \$250,000 to \$370,000.

The Scobell-Mill Chemical Company, Inc., Rochester, N. Y., has been incorporated to deal in chemicals, drugs and factory supplies. The capital is \$10,000, and the incorporators are A. H. and A. H. Miller, Jr., and G. W. Scobell.

S. Slobotzky, Inc., 154 Nassau Street, New York City, has been incorporated to deal in chemicals, products, dyestuffs, extracts, drugs, merchandise. The capital is \$10,000, and the incorporators are W. Schaefer, A. S. Slobotzky and S. Slobotzky.

Solvay Coke Company will hold a stockholders' meeting at Ashland, Ky., Nov. 1, in order to pass on a proposition to increase the common stock from \$1,300,000 to \$500,000. The increase will be used for additional coal lands and the development of the company's coke plant.

Somers Company, Inc., Waterbury, Conn., has been incorporated to manufacture metals and machinery. The capital is \$50,000. The incorporators are Joseph E. Somers, Robert D. Somers and Louis J. Somers.

The Suriman Trading Company, Ltd., New York City, has been incorporated to act as commission agents and agents for lumber, wood, paper and pulp. The capital is \$100,000, and incorporators are G. R. Foody, L. J. Ingeoino and W. H. Thomas.

The Tacoma Lumber Products & Fertilizer Company, Tacoma, Wash., has been incorporated in Washington with capital of \$50,000. The incorporators are J. B. Agner, I. Carpenter and L. Y. Staton.

The Taylor Instrument Company, Rochester, N. Y., have increased their capital from \$35,000 to \$50,000.

The Teluride Mines Corporation has been incorporated in Delaware with a capital of \$500,000 to carry on a general mining business. The incorporators are Bertram Schaefer, Frank Schaefer and August Schaefer.

The Thrall Oil Refining Company, Thrall, Tex., has been incorporated at Austin, Tex., with a capital of \$20,000. The incorporators are Fritz Fuchs, L. W. Fuchs and F. C. Klotz.

The Transport Oil Corporation, 43 Cedar Street, New York, has been incorporated in New York with a capital of \$20,000. Lieberman and R. Lockwood.

Trumbull Steel Company, of Warren, Ohio, directors have authorized the issuing of \$3,750,000 common and preferred stock to take care of plant extensions.

The Tungsten-Gold-Silver Production Company, Boulder County, Col., has been

incorporated at Denver, Col., with a capital of \$100,000. The incorporators are R. R. Moodie, A. R. Pattee, N. M. Abbott.

The Tygerine Oil Company has been incorporated to manufacture and deal in oils and compounds. The capital stock is \$200,000. The incorporators are Ferris Giles, K. M. Dougherty and L. S. Dorsey, of Wilmington, Del.

United Alloy Steel Corporation, New York City, has been incorporated with a capital of \$25,000. The incorporators are R. Bennett, Jr., W. K. Dupree, Jr., and R. Sherman.

The United States Drug & Chemical Company, Cleveland, is a new corporation with a capital of \$250,000.

The United States Company of Canton, Ohio, has been sold to a New York syndicate, headed by Hornblower & Weeks, bankers, for \$16,000,000. About \$4,000,000 will be spent in improvements and the name will be changed to the United Alloy Steel Company.

The Utility Distributing Company, Wilmington, Del., has been incorporated to deal in and manufacture chemicals, compounds, combinations to be used in removal of carbon and prevent formation of carbon. The capital is \$1,000,000. Representative, C. J. Coleman, 1465 Broadway, New York City.

The Washington Copper Company, Seattle, Wash., has been incorporated in Washington with a capital of \$1,000,000. The incorporators are Joseph Silver, L. J. Riley, Charles Osmond, W. A. England.

West End Oil & Gas Company, Wilmington, Del., has been incorporated to acquire oil and gas lands and to develop them. The capital is \$1,200,000. The incorporators are F. D. Buck, George W. Dillman and M. L. Harty.

The Western Glass Company, St. Marys, W. Va., has been incorporated with \$50,000 capital to manufacture glass.

The Western Process Company has been organized at Portland, Me., with a capital of \$50,000. The company will carry on the business of mining, milling, smelting and refining of various metals, gypsum and coal. The officers are Frederick H. Cobb, president; C. W. Smith, treasurer, both of Portland, Me.

The Weston Glass Company, of Pittsburgh, Pa., has been incorporated at Cincinnati, Ohio, with a capital of \$50,000. The incorporators are R. S. Gies, Charles V. Arbogast, F. W. Stonecipher, L. K. Voelker, of Pittsburgh, and Van J. Kuntz, of Jeanette, Pa.

The West Virginia Waste Wood Chemical Company, Inc., has been incorporated to develop processes and machinery for destructive distillation of wood and other raw materials, with a capital of \$330,000. The incorporators are H. M. Vayard, R. Kirby and W. M. Baldwin. The office is at 17 Battery Place, New York.

White Cross Copper Company, Wilmington, Del., is incorporated to manufacture, sell and deal in and mine gold, silver, copper, etc. The capital is \$1,000,000. The incorporators are F. D. Buck, M. L. Harty and K. E. Longfield.

Wilcock & Vaughn Company, Inc., New York City, has been incorporated to manufacture iron, steel, mining and railway equipment. The capital is \$25,000, and the incorporators are M. L. Welland, A. H. Slack and H. Amerman.

The Wright Chemical Corporation, Newark, N. J., has been incorporated to manufacture chemicals. The capital is \$100,000 and the incorporators are Elma J. Wright, Anna G. Wright and Anna C. Crocker, of Brooklyn.

Construction and Operation

Alabama

BIRMINGHAM—The Linde Air Products Company has given contract for the erection of a plant to produce oxygen at Birmingham, Ala.

California

FAIR OAKS—The Fair Oaks Fruit Company has decided to spend from \$12,000 to \$15,000 during the next year in enlarging the plant. The pipe and process plant will be increased and a solvent plant for the saving of the grease in the olive seeds will also be constructed.

LONG BEACH—The Marine Chemical Corporation, which has been operating a plant here for some months, will increase its capital from \$60,000 to \$300,000 and build a large factory in the harbor district

for the manufacture of products from the waste bittern water from salt refineries. The officers of the company are J. M. Keat, president of the California Southern R. R.; S. E. Muesser, chemist, and C. T. Whittier, president of the United Oil Company. The plant is located near the Long Beach Salt Works.

LOS ANGELES—The Warman Steel Castings Company of Los Angeles, Cal., has announced the erection of three foundry buildings at Huntington Beach, to cost \$100,000. The company's plant at Redondo Beach will be moved to the new location.

OAKLAND—The Paraffine Paint Company, Oakland, Cal., has practically doubled its capacity by additions to its plant.

PETALUMA—Monte Button of San Francisco has purchased land on the waterfront and intends to erect a paint factory.

SAN MATEO—The Whitney Chemical Company has commenced the manufacture of epsom salts, magnesium chloride and potassium chloride from sea water at San Mateo, Cal. The company is working in conjunction with the Leslie Salt Refining Company. Sea water is evaporated in ponds and the salt removed, and the potassium and magnesium salts are obtained from the remaining liquor.

Connecticut

CANAAN—The Connecticut Chemical Company, of which William M. Barnum, of New York, is the head, will erect a wood distillation plant at Canaan, Conn., for the manufacture of acetate of lime and wood alcohol. The cost of the plant is estimated at \$250,000.

NEW HAVEN—The Baumann Rubber Company, New Haven, Conn., has awarded the contract for the erection of a new three-story factory, 75 by 32 ft., to cost \$20,000.

District of Columbia

WASHINGTON—Bids will be received at the Bureau of Supplies and Accounts, Navy Department, Washington, D. C., for furnishing at the various navy yards and naval installations supplies as follows: Mare Island, Cal., Schedule 237—five automobiles and one pulance; Schedule 237—1000 5-cp. instrument lamp sockets 2000 lb. copper pipe. Puget Sound, Wash., Schedule 237—six engine room clocks, 235 lb. 20-in. by 48-in. hard sheet rubber; Schedule 294—six 220-volt, alternating-current motors. Charleston, S. C., Schedule 316—two engine room and fire room clocks, one steam-driven air compressor, two indicators for auxiliary engines, one steam whistle. F. O. b. works, Schedule 316—200,000 minor caliber tracer fuses. Washington, D. C., Schedule 317—800 lb. lead wire, 10,000 lb. soft copper sheets in strips, 4100 ft. galvanized iron pipe. Brooklyn, N. Y., Schedule 305—miscellaneous insulator construction cable, 10,000 ft. telephone cable, 12½-in. portable electric drills, 12 double scale portable voltmeters, miscellaneous twin-conductor wire. Various. Schedule 329—3300 ½-in. to 7½-in. spark plugs. Norfolk, Va., Schedule 303—miscellaneous brass sheet, 40,000 lb. manganese ingot bronze, miscellaneous copper bar, 150,000 lb. ingot copper, miscellaneous sheet copper. Applications for proposals should designate the schedule desired by number.

Illinois

CHICAGO—Swift & Company has announced that it would erect a 7-story soap factory to cost \$200,000.

Indiana

GARY—The American Car & Foundry Company will erect a large plant at Gary, Ind., to employ 4000 men. Actual construction will not be commenced until early in the winter.

GARY—The U. S. Steel Corporation plans to make vast extensions at Gary, Ind., according to information disclosed in a recent case in the Circuit Court at Valparaiso, Ind. Suit was brought against subsidiaries of the steel corporation by trustees of the Mander estate to prevent Grand Calumet River restored to its original contour, to connect it with Gary Harbor and open it to the public. The corporation contends that it had to change the river to build its plant, and that it is impracticable to use the harbor for general commercial purposes. During the hearing it was disclosed that four new furnaces will be built, also a new Bessemer duplexing mill. The National Tube Company will erect four blast furnaces, docks, a Bessemer mill and auxiliaries. The American Locomotive Company and the American Car & Foundry Company have acquired sites for new plants in Gary.

MUSKOGEE—Officials of the Ball Glass Manufacturing Company, of Muncie, Ind., recently visited Muskogee in order to obtain information on the gas fields relative to

Kentucky

LOUISVILLE—The Security Producing & Refining Company, Louisville, Ky., is planning the erection of an oil refinery.

Louisiana

BOGALUSA—Construction has been started at Bogalusa, La. of a large paper mill; cost about \$1,000,000. It will have a capacity of 75 to 90 tons of paper per day, and is being erected by the Bogalusa Paper Company, of which G. H. Wood is the head.

Maryland

BALTIMORE—The Columbia Paper Company, Baltimore, Md., will erect a new addition to its East Fort Avenue plant. Plans have not yet been given out.

BALTIMORE—The Penn Mary Steel Company, Baltimore, Md., is having estimates prepared for the erection of an addition to their gas engine plant, which will cost when equipped about \$400,000. The new addition is to be of brick and fireproof construction, one story high, with overall dimensions of 90 by 200 ft. The engines which will be installed in the new addition will be used in connection with the blower system of the steel works.

CANTON—The Coco-Nut Oil Products Company, a New York corporation, has let the contract for the erection of a plant at Canton, Md., to cost \$150,000. Extensive machinery and equipment will be installed for the extraction of oil from coconuts.

SPARROWS POINT—The Bethlehem Steel Company will erect a by-product coke plant at Sparrows Point, Md., to cost \$2,500,000. The U. S. Koppers Company is preparing the plans.

Massachusetts

BOSTON—The Revere Sugar Refining Company, Boston, Mass., is preparing plans for a new group of buildings at Charlestown. One of the largest buildings will be nine stories high of brick, steel and stone, and will cost \$1,000,000. A filter house will also be built, nine stories high and 101 by 72 ft., costing \$161,000. A six-story brick, steel and stone building, to be known as the meter house, will also be erected. This will cost \$40,000.

PALMER—The Whittall Carpet Mill, Palmer, Mass., has let the contract for a dyehouse to cost \$12,000. The building will be one story high, 110 by 40 ft.

Michigan

BENTON HARBOR—The Superior Steel Castings Company's new plant is rapidly nearing completion. The steel skeleton work is finished, and although considerable difficulty was encountered in securing cars to haul sand for filling, it is expected that the plant will be finished by Dec. 1.

DETROIT—The John A. Crowley Steel Company is erecting an electric steel plant in Delray, a suburb of Detroit. Grönwall-Dixon furnaces will be used.

HOLLAND—The Holland Aniline Company will shortly start operations at its new plant and expects to turn out Bismarck brown. The company has its own power house, pumping station and gas plant. The manufacture of methyl violet and methylene blue is also contemplated.

HOLLAND—The Holland Furnace Company, Holland, Mich., is erecting a new foundry, 60 x 230 ft., adjacent to its present buildings. The new foundry will double the company's capacity and add 100 men to its force. Mr. A. H. Landwehr is manager of the company.

MANISTEE—The Filer Fibre Company, a newly organized company, plans the erection of a pulp plant to be completed within eight months.

Minnesota

BEHMIDJIE—A modern foundry is being erected by the Behm-Wilfong & MacLane Company, Behm, Minn., to manufacture all kinds of iron, brass and cast mixture castings. The output will be three tons per day.

ST. PAUL—Plans to order work by the Electric Steel Company, a new concern, for a steel manufacturing plant to make electric furnace steel castings. Ten acres have been

purchased at Lexington Avenue and Great Northern Railroad. G. W. Harrison is president of the new company.

Missouri

ST. LOUIS.—The Lincoln Steel & Forge Works has acquired four acres of land at Natural Bridge and Goodfellow Avenue, and is erecting buildings for the manufacture of structural steel.

Montana

HAMILTON.—The Montana-Utah Sugar Company has ordered the machinery for its new factory at Hamilton, Mont. This will be delivered next March. The contract for structural steel work has been let.

New Hampshire

FRANKLIN FALLS.—M. T. Stevens & Sons, Lawrence, Mass., have let the contract for the new property of Worcester, and is erecting a new dyehouse at its Franklin Falls, N. H., plant, to cost \$30,000.

New Jersey

MARCUS HOOK.—A two-story factory building will be erected at Marcus Hook for the Benzol Products Company, at a cost of \$35,000. The contract has been let for F. W. V. Loom.

MILLVILLE.—The Millville Manufacturing Company, Millville, N. J., which employs about 500 hands in their bleach and dye works, has given the contract for a large concrete plant which will almost double its capacity.

NEWARK.—An addition will be made to the plant on the Hackensack River of the White Tar Company of New Jersey, at a cost of \$30,000. The concern will refine naphthalin.

PATERSON.—The Standard Oil Company of New Jersey will erect a new distribution station at Paterson, N. J., to cost \$100,000. There will be three buildings, the largest being 75 by 100 ft. The contract has been awarded to the H. D. Best Contracting Company. Samuel B. Farnum is Paterson manager of the Standard Oil Company.

PATERSON.—The Victory Silk Dyeing & Finishing Company, Paterson, N. J., is erecting a one-story mill to cost \$42,800.

TRENTON.—The New Jersey Chemical Company, 145 North Willow Street, Trenton, N. J., is operating a process for the recovery of zinc from scrap galvanized iron, with the production of zinc oxide, and zinc free scrap iron. The officials of the new company are Thomas Shegog, Abraham Bersek and David Berkow.

New York

BROOKLYN.—The W. Beckers Aniline and Chemical Works, Brooklyn, N. Y., manufacturers of Byproducts, will hold a stockholders' meeting on Nov. 2 for the purpose of voting on a stock increase from \$2,000,000 to \$5,000,000 for the purpose of enlarging the plant.

BUFFALO.—The Commercial Electrolytic Corporation, the new company, has acquired a site in Buffalo and will erect a factory for the manufacture of hydrogen peroxide. About 1000 hp. of electrical energy has been contracted for.

BUFFALO.—The Schoellkopf Aniline and Chemical Works are having two three-story factory buildings erected at a cost of \$40,000.

CARTHAGE.—The Island Paper Company will build a new mill at Carthage, N. Y., on what is known as Tannery Island. The cost is approximately \$100,000. The building will be two stories, 83 by 79 ft. Charles W. Pratt is president of the company.

COHOES.—The Frank Gilbert Paper Company has let a contract to C. P. Boland & Company, of Troy, N. Y., for the erection of a paper plant at Cohoes, N. Y. The new plant will cost about \$100,000. It will include a machine room, finishing mill, sulphite mill and power house. The plans were formulated by Thomas L. Tomlins, consulting engineer of Watertown. Brick and steel construction will be used and the most modern equipment will be installed.

DUNKIRK.—The Dunkirk Glass Company, of Dunkirk, N. Y., has announced that it will double the size of its plant. The principal addition will be a two-story building, 30 by 200 ft. The new furnaces will add at least 50 men to its force.

Hudson Falls.—The Union Bag & Paper Company will erect a new plant at Hudson Falls, N. Y., adjacent to its present plant. The new building will be 100 by 100 ft. and will employ about 100 persons.

JOHNSON CITY. Construction will be commenced in March, 1917, by Endicott,

Johnson & Company, Johnson City, N. Y., of an immense sole leather tannery to cost \$750,000. The new tannery will be located to the west of the present sole leather tannery and will have a capacity of 4000 sides per day. The present sole leather tannery has a capacity of 2500 sides per day. A new power plant will also be built. George W. Johnson, superintendent of tanneries, is now in the West inspecting large tanneries for the purpose of obtaining ideas on construction.

LONG ISLAND CITY.—The Cambridge Silk & Chemical Company has purchased a site at Harris Avenue and Hamilton Street, Long Island City, and will shortly erect a plant.

NEW YORK.—Richmond Levering & Co., 120 Broadway, New York, contemplate the erection of a potash plant on the Hudson River to cost \$1,000,000. Sketches are being prepared by J. Norman Bulkley, architect and engineer. The exact location has not yet been made public.

NIAGARA FALLS.—The Carborundum Company will erect an administration building on the property of the Niagara Falls Power Company. The present offices will be used as a research laboratory by the Massachusetts Institute of Technology in conjunction with its new course in chemical engineering practice.

NIAGARA FALLS.—Almost all of the output of the new \$2,000,000 steam-electric plant of the Buffalo General Electric Company, at Niagara Falls, has been contracted for within 25 miles.

Ohio

COLUMBUS.—The Ohio Malleable Iron Company, Columbus, Ohio, is erecting an addition to its plant on the North Side, to cost \$70,000.

COSHOTO.—The Coshocton Glass Company, Coshocton, Ohio, is having plans prepared by H. L. Dixon & Company, of Pittsburgh, for a new bottle factory, to cost \$100,000, and employ 150 men. The new factory will double the capacity of the plant to 150,000 bottles per year.

LORAIN.—The J. C. Cromwell Steel Company of Cleveland, Ohio, has let contracts for its new steel mill to be erected at Lorain, Ohio. The blooming mill will be built by the Adams Structural Company, and other work by the Alliance Machine Company.

LORAIN.—The United States Steel Corporation is considering plans for the erection of a new steel plant here to employ 6000 men.

MASSILLON.—The National Pressed Steel Company plans the erection of a new plant in Massillon, Ohio, to manufacture hot and cold-rolled strip steel and metal lumber. The new company is allied with the Massillon Rolling Mill Company and the National Steel Company of Massillon. R. E. Bebb is president of all three companies.

NILES.—The Fostoria Glass Works has begun the erection of a new addition to its plant, which will increase its capacity more than one third. N. J. McMahon is superintendent of the plant.

NILES.—Work is progressing satisfactorily on the construction of the new plant of the Grasselli Chemical Company, a short distance west of Niles.

NILES.—The Niles Glass Works, Niles, Ohio, a subsidiary of the National Electric Lamp Company, has awarded to the Austin Company, of Cleveland, a contract for a new building to cost \$50,000.

WARREN.—The Trumbull Steel Company, of Warren, Ohio, will erect ten open-hearth furnaces of 100 tons capacity each, and also a 40-in. blooming mill and bar mill. The United Engineering & Foundry Company will furnish the mills and the Ritter-Conley Company the steel.

YOUNGSTOWN.—A new battery of by-product ovens is contemplated by the Republic Iron & Steel Company, of Youngstown, Ohio. Plans have been prepared for a battery of forty-six or forty-seven ovens which will bring the capacity up to 5000 tons daily and the ovens up to 190. The installation will cost \$1,000,000 and everything is ready for the directors to authorize the extension. Mr. J. W. Veitrick is general manager of the company.

Oklahoma

ADA.—A new glass factory to manufacture fruit jars is contemplated at Ada, Okla. Fruit jar manufacturers from Wichita Falls, Tex., have been looking over the natural gas fields.

OKLAHOMA.—The Oklahoma Refinery Company, Okla., will erect a new warehouse costing \$30,000, to replace buildings recently destroyed by fire. Mr. K. R. McKee is president of the company.

Oregon

WILLBRIDGE.—The Pacific Coast Steel Company has selected a site in Willbridge, Ore., for its proposed plant after months of negotiation. The property lies just north of the plant of the Shell Oil Company, and comprises fifteen acres.

Pennsylvania

BRIDGESBURG.—The Abrasive Metal Company will erect a new crushing plant at Bridgesburg, Pa., consisting of a building 82 by 86 ft.

GLENSHAW.—A site has been purchased here by a West Virginia glass manufacturing firm and it is the intention to erect a modern glass plant. The land was purchased through the McConnell Company, of Pittsburgh.

MOUNT UNION.—The plant of the Aetna Explosives Company, at Mount Union, Pa., which has been idle for some time, will be used for the manufacture of dyes and sulphuric acid.

PHILADELPHIA.—The Henry Bowker Chemical Company will erect a one-story brick shop, 50 by 60 ft., to cost \$3,000.

PHILADELPHIA.—The Chamber of Commerce of Philadelphia has given out the information that two great metal plants, employing 10,000 men, would shortly locate there. The names of the concerns and the exact nature of the work have not yet been made public. River and rail facilities, the presence of skilled labor and proximity to raw materials were deciding factors.

PHILADELPHIA.—A large iron foundry will be erected on the Schuylkill River, Thirtieth Street, below Locust, Philadelphia, Pa., by Morris, Wheeler & Company. The property known as the "old paper mill plant" has been acquired. This property was formerly owned by the Continental National Bank of New York.

PHILADELPHIA.—Three buildings, one 150 by 50 ft., and two smaller, will be erected at the northeast corner of Sixty-first Street and Eastwick Avenue by the H. A. May Foundry Company.

Texas

BAY CITY.—Plans for the erection of a peanut-oil mill are being made by V. H. Sledge, Bay City, Tex.

TEXAS CITY.—The Texas Resources Development Company is considering plans for the construction of blast furnaces and a steel plant to handle ore from Cass County, Tex.

Utah

OGDEN.—The Continental Oil Company plans to erect a new plant to cost \$40,000 on land recently purchased. The plant will consist of a two-story concrete and brick warehouse, pump house and six new tanks, with a combined capacity of 200,000 gal. Joseph F. Campbell is superintendent.

Virginia

FREDERICKSBURG.—The National Dye Corporation of New York will begin the manufacture of dyes at Fredericksburg, Va., in a short time. The company has acquired the plant of the former of the Fredericksburg, Va. The plant will be enlarged and additional machinery installed.

Washington

TACOMA.—The Standard Chemical Company has leased 75 ft. of waterfront at Tacoma, Wash., to be used for manufacturing purposes and will double its present plant there. The officers of the company are Paul Van Horst, president; W. A. Lenenberger vice-president; W. C. Morrow, secretary, and J. E. Berkheimer, treasurer.

West Virginia

CHARLESTON.—The Roessler & Haas-lacher Chemical Company of New York has purchased 175 acres of land, 14 miles from here, and will erect a \$1,000,000 plant.

Wisconsin

MILLI.—John Strange, of Neenah, plans the erection of a paper and pulp mill to manufacture Kraft paper.

Metallurgical and Chemical Engineering

A Consolidation of
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Where Will These Profits Go?

There is a great deal of jubilation these days over the profits we are making. It is said that we are growing rich; the wealth of the United States is increasing rapidly. The common concept appears to be that of taking the United States as a business enterprise; its raw materials are costing it so much and its sales of finished product are vastly larger, hence great profits, paid us in gold, in Anglo-French bonds, French rentes, etc., and in American securities formerly held by our customers.

Now, we want to know. What is there in this? Some who have studied the matter, with statistics a-plenty, find that our favorable trade balance since the war started has enriched us, to Oct. 1, by more than four billion dollars. That is a huge sum, so large that it may silence argument, and yet we may venture to study it a little. Suppose it reaches five billions in the near future, as probably it will. What is the United States going to do with it? Suppose "we" invest it at 6 per cent. Then we should have \$300,000,000 a year income, or \$3 a year for each man, woman, and child of us. We are pensioned off, and don't need to work any more. Every three months we deposit our coupon in the bank and draw seventy-five cents, less three-quarters of a cent income tax unless we can claim exemption.

Now, the seventy-five cents every three months may do us good, but the idea that we don't need to work any more won't do us any good. We have known such an idea to do people harm, even when it was true, and in this case it isn't. There are a great many cases of a young man being trained up to work like his father and suddenly pater dies without having tied up his estate, and the young man goes the pace.

Of course, our relations with the world are changed. We shall not need to export much more merchandise than we import, insofar as we have hitherto had to do so for the purpose of paying interest and dividends on such of our securities as were held abroad. The securities have been largely returned to us, and we have purchased foreign securities, so that in future we can, so far as this goes, import more merchandise than we export. But there is an item we have noticed that is often lost sight of. Something occurred whereby the securities mentioned originally came to be held abroad, and it appears that the occasion was that we did not export a sufficient surplus of merchandise, over what we imported, to break even. That was a bad habit to get into and with this new idea of ours, how rich we are, we may become still more confirmed in that habit, and that is certainly not a good thing either.

As a matter of fact, this business of the United

States is not that of a corporation. It is merely the aggregate of what individuals, firms and corporations are doing. It is a question of what the individuals will do. The profits are not distributed per capita, but are somewhat tightly held. The prosperity of the country is simply the prosperity of the individual. If the individual's ordinary living expenses are increased, by these times, more than his income, he is worse off. He spends as much but he receives less in return, in quantity. Those who are amassing large profits will in time spend them or invest them. That sounds good, but a rather clear argument can be built up that periods of industrial depressions in the United States have always followed periods in which there was too rapid conversion of liquid into fixed capital, too much new construction. *Post hoc, ergo propter hoc.* If the people had been able to patronize the works built they would have earned money year by year, but they could not do so. Which suggests that if the war is to be followed, as is generally being predicted, by a great rush of capital into investment in the United States, the success of the ventures is going to depend largely upon whether the rank and file will find themselves in position to patronize the new factories, or mines, or stores, or whatever it may be that are going to be established.

Guayule Rubber

We print in another column a contribution on Guayule rubber, which we commend to the thoughtful consideration of our readers. It made us thoughtful in another way at the very first glance; thoughtful of Intercontinental Rubber with dividends of 4 per cent on common stock and prospective earnings way up—say 50 per cent.

It was a romantic story. There was any amount of Guayule shrub in Mexico which was brought in by peons, as our correspondent says. The trouble at this point, as he also intimates, was that the peons, in true Mexico-Berserker fashion, ripped and tore up by the roots everything that grew in the desert except cactus. The cacti were spared by their spines. So the doomsday of desert rubber hove in sight. But in the bright lexicon of a rising stock market there's no such word as fail. Land was secured and water brought down from the mountains for the culture of the plant of dolor, under enlightened conditions. The shrub was accustomed to a hard life with little water; so it took about thirteen years to mature on its native wastes. Our correspondent refers to five years as the time for maturity, which may be the period under modern culture. We do not know, except that "they said" in the grand old days of dividends and desires in sight, that it took about thirteen years out in the desert. In the meantime it had been discovered that with the help of irrigation the plant matured in two years, and the stock of the Intercontinental Rubber bounded skyward. The tip was passed around that they had the whole rubber situation "cinched"—which was a good, if not a final argument.

Following this came another discovery that the shrub, transplanted to more favorable surroundings with the precious water, theretofore so scarce, brought to it in

such abundant measure, had no more need to secrete a heavy sap—and so it didn't. It grew like a green bay tree, but it did not grow rubber.

Now followed the beginning of the present series of Mexican revolutions, and Intercontinental stock tumbled. It ceased to be banking collateral, and it was, in the language of the street, "closed out" in many instances. There are, however, always insiders and outsiders, and, as is usually the case, the outsiders ceased to believe in guayule rubber. It was inferior at best. Crude guayule, as it was called, brought about 60 per cent of the price obtained for up-river fine Para and Ceylon plantation. It was sticky and messy. But it was rubber, and rubber chemists knew how to deal with it. They also knew how to mix it. So those who believed in guayule did the unusual thing and took professional advice—botanical advice, in fact. Lately a rumor has grown current that this has met with marked success after patient research. Information as to details is not available, but the rumor persists that the shrub may be and is grown under irrigation in Arizona, and by that learned and judicious strategy which is the substance of research, the irrigated plants do secrete the gum in abundant measure.

That we should have a source of rubber supply within our shores is very desirable. We hope, with an enthusiasm so intense that we should only appear ridiculous if we were to try to express it, that war may go out of fashion, but the wish does not remove the need of self-containment by nations.

Here, then, is a rubber-producing shrub that may be grown in the United States. The extraction of the gum and its chemical treatment is reasonably provided for. The problem whether it may be grown economically or not is a question within the great realm of botany. It is exceedingly interesting, and proves again the need of the correlation of all the sciences in industry.

Railroads and Iron Production

Car shortages throughout the country direct attention to the dependence of the iron and steel industry upon the railroads. It is feared that a railroad blockade, comparing in seriousness with the memorable one of 1902-3, will be upon the country within a few weeks, for railroad facilities are already strained to their utmost and the change that may occur overnight from very favorable to distinctly unfavorable weather conditions will instantly reduce the train movement. When the railroads are working at their best the first cold snap of early winter always slows down the movement, whereas of late they have been working with difficulty and with no reserves of motive power or men.

Pig iron is being made at the rate of about 114,000 gross tons a day. The major portion of the ore consumed, probably about 90 per cent, must be moved by railroad for longer or shorter distances, involving about 195,000 tons of ore a day. About 75,000 gross tons of the coke consumed moves by rail, and substantially all the limestone, about 55,000 gross tons. The amount of slag that must be removed by rail may be roughly

estimated at 25,000 tons. About 40,000 tons of the pig iron produced is carried away by rail, the balance being consumed at the point of production. Here is a total of 400,000 gross tons daily of freight movement over railroads involved in blast furnace operations alone. For each ton of steel ingots produced there is required about one net ton of coal, for steam and gas at the steel works, while some finishing operations require large quantities of coal. In the making of tin plate the steel is heated six times, four times in the rolling process and twice for annealing. Allowing that only two-thirds of the steel industry's coal consumption is moved by public railroads the daily coal movement is probably about 50,000 gross tons. The movement of semi-finished steel from steel mill to finishing mill, as in some cases the operations are detached, and the movement of finished steel products from mill, involve more than 100,000 tons a day in addition. Making allowance for incidentals, there is a total railroad movement of about 600,000 gross tons per day to take care of the blast furnaces and steel works, disregarding entirely the foundries. The computation is on the basis of movement each of the seven days in the week, although loading and unloading is usually confined to six days. This represents about 250,000,000 net tons a year, or about one-eighth the total freight movement of the railroads, disregarding mileage. Inasmuch as the iron and steel industry is confined largely to certain districts the proportion is very high in the iron and steel sections.

For the iron and steel industry to operate at its best, for it to produce the tonnage to which its units are in themselves physically adequate, it is necessary that nearly all of this freight movement be continuous from day to day. The flow must be steady. The modern beehive coke oven is equipped with automatic drawing and loading machinery, and cannot stock coke. It is inconvenient for the blast furnace to stock coke. Coal storage facilities are usually limited, while at the present time there are no stocks, irrespective of the storage facilities. The blast furnaces equipped with casting machines usually load directly to the railroad car. The stocks of pig iron are almost *nil*; if pig iron production decreases the steel making units must slow down, and there are practically no stocks of cold ingots, or of billets, slabs, sheet bars, etc. If the steel mill slows down, so must the finishing mills. If the finished steel products cannot be shipped the production must in many cases be curtailed.

Thus any curtailment in shipping facilities is certain to decrease the production of iron and steel, at a time when the industry is straining every nerve to produce the maximum. A decrease in steel production will not operate to prolong the period of heavy demand, for the limit is not one of tonnage, but of time, meaning the end of the war. After that there will be new conditions, and of course new demand, but that will be an entirely separate period with its own times of delivery and its own prices. The present task is to produce the maximum number of tons before the time limit is reached.

Electric Properties and Microstructure

The mechanism of electrical conduction through solids has been the subject of much mathematical speculation on the basis of the electron theory. Recently, however, the subject has been attacked experimentally from a new viewpoint with considerable success. The new viewpoint is the connection between electric conduction and microstructure. It is an exceedingly profitable and promising viewpoint.

In our issue of Oct. 15 (page 464) we published a full abstract of a very interesting paper of fundamental importance by Dr. Colin G. Fink read at the last New York convention of the American Chemical Society in which the conclusion is reached that the electrical conductivity of a substance is primarily dependent upon the shape and the distribution of the fundamental grains or particles comprising the substance, and secondly, upon the presence or absence of thin films of secondary material enveloping these ultimate grains. On the basis of this theory it is possible, as Dr. Fink points out, to account for the comparatively high conductivity of gels that contain but a trace of conducting material. It is also possible to account for the marked difference in resistance, for example, of two samples of commercial copper, whose chemical composition is identical, depending upon whether the impurity, such as sulphur, is uniformly dissolved in the metal or whether it forms a film ("cement") of copper sulphide around pure granules of copper. The latter case is to be regarded, as Dr. Bancroft suggests, as an emulsification of copper in copper sulphide. The high resistance of these surface films composed of, say, sulphide or oxide or arsenide accounts for the high resistivity values of copper where but a trace of the impurity is present.

A paper by Prof. Edward D. Campbell of the University of Michigan, presented at the recent London meeting of the (British) Iron and Steel Institute, deals in a suggestive way with a closely related subject. The paper discusses the influence of heat treatment on the thermo-electric properties and specific resistance of carbon steels. The paper gives the results of a large number of tests of carbon steels ranging from 0.018 to 1.05 per cent in carbon and differing little otherwise so that the results are comparable. For each sample the electric properties depend very largely on the heat treatment because the heat treatment determines the microstructure, and, in fact, from the table of the specific resistance the progress of the precipitation of the carbides, due to heat treatment, can be easily followed. Further, there is a distinct parallelism between the thermo-electromotive force and the specific resistance of the different steels, as influenced by chemical composition and heat treatment, and Professor Campbell concludes that both the total specific resistance and the total thermo-electromotive potential of steel are made up of two components: that due to the solvent iron and that due to the carbide solutes. Professor Campbell concludes that this parallelism is strong confirmatory evidence of the essential unity of mechanism of the nature of solid solutions and of aqueous salt solutions.

Readers' Views and Comments

Research Needed in Automobile Factories

To the Editor of Metallurgical & Chemical Engineering

SIR:—Despite all that's said about the incorruptibility of the press, and granting every word of it, the fact remains that the advertiser, the large, full-page, affluent advertiser, is less likely to have his faults made clear than the wayward brother who has been caught with the goods. So the advertiser sometimes suffers from lack of sound advice while the wayward one may get even more than is good for him. This is not intentional; it just happens so.

For instance, there are the automobile manufacturers. They have been signally successful and they are grand advertisers! They take space in a way to fill a newspaper office with joy. While the business management wears out sole leather picking up little dribbles here and there and feels triumphant over the disposal of a quarter-column, the automobile man calls for two full pages, regularly, for several months. Then he discounts his bill—which sometimes seems like a great kindness. It is hard to speak save in favor of a man like that!

On all sides, too, editors hear of the marvelous mechanical efficiency of their works; how they seem to have matters down to such a system that trainloads of iron, steel, upholstering materials, rubber for tires and noise for horns to go in, each at its separate entrance, and down the grand slide come great processions of finished cars, perfect in every detail, propelled by their own power. It is glorious!

But suppose this little unconscious advantage did not exist in favor of the advertiser and the automobile man had not enjoyed that freedom from criticism which experience may be teaching him to regard as his vested right. Suppose he had been looked upon as common clay—as an oil refiner, let us say. Things might have been different.

Here is a great industry engaged in the manufacture of machines and their accessories. The machines are explosion engines and the accessories are, in fact, wagons. It is not, when we come to think of it, such an overwhelming problem. It is like opening up a rich mine: it takes engineering skill and good management. When you come down to it, it hardly calls for supreme genius; especially when we consider the number of men engaged in it, the whip of competition and war-time profits. Let us, however, grant all the praise that is demanded; admit everything that is wished for; compare the automobile engineers and manufacturers with George Washington, Abraham Lincoln, Charlemagne, Cyrus of Persia, Alexander the Great—do everything possible to make things satisfactory and then take a little inventory of conditions.

Here is a great industry making automobiles. They are driven by gasoline. There is not enough gasoline to go round; automobile production is increasing faster than gasoline production. So the price of gasoline goes up. The increase of fuel costs affects the sale of motor cars and thus we meet the familiar situation in which "something must be done."

The manufacturers have responded by the time-honored process of cussin' out the Standard Oil Co. It has the merit of ease, tradition, and the Standard people are used to it. Whether it is good for them or not we shall not undertake to say; we only know that to blame

the old Standard company or its amazing progeny for any ill that may occur seems traditionally correct; and nobody complains. If the price of gasoline goes up, of course the Standard Oil Company is to blame and as for the other refiners, they are easily dispensed with with the remark that they are "in the ring." Then the time is ripe to whack the refiners again. "And gasoline ain't as good as it used to be," say the ultramillionaires of the automobile. We have even heard threats that the automobile makers will refine oil themselves, and then, by gosh, by golly, by Judas, by guy, by ginger, by crackey, by gum—they'll just take and go to work and make gasoline!

When people grow as rich as the automobile men it is hard to think that others are doing their best. And yet the oil refiners have been at work. The task of furnishing enough gasoline has been even more difficult than profitable—and that is saying a great deal.

Now the design of an engine to be propelled by gasoline is legitimately the problem of the automobile engineers, but the restriction of these engines to the use of gasoline has also been a self-imposed limitation by the same group of savants. There is kerosene and export oil, both hydrocarbons that explode with air and are available for explosion engines. The oil refiners may be induced to sell these fuels at really low prices without either moral suasion or threat. True, they are a little difficult to start when used in the place of gasoline and they do coke up the cylinders, which are faults that may only be remedied by research. It is a problem in chemistry and mechanics. Whether it may be accomplished by an oxidizing agent or a new carburetor or some little twist o' the wrist is a question to be answered by research. Some trucks are beginning to operate with part kerosene or nearly all kerosene, but the art is not yet developed. The automobile people have the testing facilities, the wealth and the opportunity far better than the refiners, because they use the fuel where-as the refiner can only sell it. But the automobile people appear to have been lazy and inert in this matter. They have not contributed their share of research. They have recognized the shortage of motor fuel and their chief contribution to the general welfare in the dilemma has been to decry the oil refiners. That is not illuminating nor is it helpful, except as it may satisfy the conscience of the automobile men; neither is the argument scientific.

We Americans have long suffered from chemical blind spots and the way to overcome them is to recognize them first. Now the automobile men have enjoyed so much praise and so little criticism that they have not become adequately alive to the fact that explosion engines may be driven by other hydrocarbons than gasoline. Instead of meeting the difficulty they have hollered at it. And we learn, usually, rather early in life, that this method loses effectiveness in the solution of problems that call for research. It seems as though the time were at hand for automobile makers to dry their eyes and spend some money on well directed investigation. It may surprise them to learn that the refiners will be glad to help them.

There has been plenty of research in the art of making gasoline, but in the art of adjusting engines to fuel and fuel to engines, those who need it most have been taking in their sleep.

PETER TEN BROECK.

New York City

Interesting Points in the U. S. District Court Flotation Decision

To the Editor of Metallurgical & Chemical Engineering

SIR:—The U. S. District Judge Bradford in handing down his decision makes a statement which should interest the mining industry very much. In the following I will quote a paragraph of the decision as printed in your issue of Oct. 15:

"In what was known as water or gravity concentration the ore was mixed with water forming the ore pulp, and through shaking or agitation of the pulp by well-known devices the metallic particles, becoming separated from the particles of gangue, and having greater specific gravity than the water, sank to the bottom, while the particles of gangue, having less specific gravity than the mineral particles, although greater than that of the water, were subjected to an up-current, not strong enough to prevent the metallic particles from sinking, but strong enough to carry the particles of gangue to the surface, where they would escape over the edge of the containing vessel or be otherwise disposed of. *Such processes, however, were far from commercially successful, being wasteful of water, of power and of a considerable proportion of the metallic particles in the slimes which were carried by the up-current to the surface and were lost with the gangue.*"

In many years of experience in the concentration of ores the writer has failed to run across a concentrating method using an up-current of water for means of water concentration. Evidently the court refers to jig practice or table concentration. In neither case, of course, an up-current is used. In a jig, as is well known, a pulsating current is used and on a concentrating table a transverse current is used. When the court described the method as "what is known as water or gravity concentration," and refers to "shaking and agitating the pulp," there can be no room left for the reader to understand that the court refers pure and simple to gravity concentrating methods. The statement made by the court that such processes, however, "are far from commercially successful" is quite radical, and can hardly be taken otherwise than that the court was unfamiliar with these methods. Millions upon millions of dollars' worth of minerals have been and still are being concentrated by the good old gravity-concentration methods, and to dispute their commercial success is doubtless a strong undertaking. It might interest Judge Bradford to know that the gravity-concentration process is still used for the concentration of by far the greater portion of the world's mineral production, and if flotation would be adapted by a great many producers who now use water concentrating methods in place of the same, they would undoubtedly suffer considerable losses. Flotation concentrates of zinc ores, for instance, is very much penalized by smelters on account of its fineness. It can also be stated that the flotation process is up-to-date unsuccessful for the commercial separation of one mineral from the other, and some flotation concentrates have to be retreated by the gravity method.

It may be true that the quotation of water concentration in the decision has no bearing upon the subject, but then why is this reference made? If, on the other hand, there is a legal value in making the comparison, then surely the decision embodies the description of a standard well-known method, which is incorrect in every detail. Some doubt must naturally arise whether or not the subject has been properly presented to the court, when right in the outset of the opinion the court refers to and compares the patent in question with an old and highly successful method of concentration, and calls same "far from commercially successful." If the patentability of the process of the plaintiff rests partially

upon the greater success attained by this process over the older methods, then surely the older methods should be well known to the court and the old water-concentration method surely deserves a little more credit than given to it by Judge Bradford.

Going on with his opinion the court states that "no one to-day understands how the use of only 0.1 per cent of oil operates to secure the mineral froth." This surely is an interesting and vital admission, aside from the legal aspect, whether or not an inventor ought to understand the workings of his own conception and whether he can be credited with and given a monopoly upon a process based upon something that he does not understand himself. This will undoubtedly be decided in due time by the higher courts. In this case, however, it is admitted that many other patents have been granted prior to the patents of the plaintiff, and practically the only difference is the very point that no one understands. Does not this at least leave the matter in very doubtful condition?

In an editorial of the same issue of the METALLURGICAL AND CHEMICAL ENGINEERING the court is credited with making the statement that the "presumption of validity arises from the grant of letters." If this holds good in one case it surely holds good in all, and why should not the inventors of the other patents cited get the benefit of that same argument when they applied for and received letters of patents upon something that they have clearly described and understood, and particularly when there are great numbers of such patents issued upon substantially the same subject as against the small minority of patents set forth by the plaintiff, which are all based upon something which neither the court, nor the experts in court, nor the plaintiff, nor the inventor understand. If a thing is not understood then this thing cannot be considered a fact. If a thing is not a fact it cannot have any standing before the law.

The court also quotes that "when the old mode of operation and its result, through a decrease in the amount of oil, disappear and a new and different result is disclosed, the change ceases to be one of mere degree and may support a patent monopoly." This is undoubtedly true, but where does the old mode of operation and the result disappear? The old mode of operation has been, and the new one is, the agitation of ores with water and oil, and the result is and has been a more or less complete separation of the mineral and gangue constituents. The quantities of oil used is, in practice if not in law, a matter of degree or rather quantity. The technical effect which is primarily a thing upon which a patent stands is the same.

I am in a position to make a demonstration of my old patented process, which has been cited in court, and in such a demonstration I am satisfied I can make a better separation than is possible with the process in question. It may be possible, although I do not feel sure about it, that the other process may make a better separation in some cases, but we all know that no concentrating process is a sure cure for every ore, and that one ore is more amenable to one than it is to the other. The great and important item, of course, in every commercial operation is economy. When an inventor is granted a monopoly over others that have worked on the same principle and produced certain results, the whole history of this process should be taken in consideration. The history shows it has been known prior to the date of the U. S. patents of the plaintiffs that sulphide mineral has a certain affinity for oil. Upon this the early start of the art was based. Agitation, of course, was necessary to bring the oil in contact with the ore. With a lesser degree of agitation more oil had to be used, and with a greater degree of agitation

the oil could be diminished. In the early beginning both Mr. Elmore and myself were working on the same principle, not knowing of each other, as well, perhaps, many others, and we all devoted our attention to the recovery of the oil after it had once been used.

In 1906 I visited the Elmore Laboratory in London. That was after I had my own process developed and patented, and both he and myself used, in those days, centrifugal driers to recover the hydro-carbons from the concentrates. I also built hydraulic presses, pressing the concentrate into briquette form, thereby extracting the hydro-carbon, but it soon became apparent that an insufficient extraction of the oil was only possible. I then devoted my attention to the reduction of the original quantity of hydro-carbon used, and I assume that everybody else active in this field did the same thing. It became largely a question to distribute the small quantities of the hydro-carbon used over the large bulk of water and ore and still bring the hydro-carbons in contact with the mineral.

Rapid agitation developed to be one means. There were other methods which I used, and patent applications were filed as early as 1906, and I am in a position to produce evidence to that fact through the U. S. Government's records. I do not feel that I should disclose at present what these means were, since by my knowledge no one else has ever attempted to use the same. This much, however, is certain, that everyone working on this principle tried to reduce the amount of hydro-carbons used to a minimum. In doing this I, for one, found that aeration was helpful, and employed same. The aeration was shown in one of my patents, and I understand that the machine used for that purpose was demonstrated in court by the plaintiff, naturally, in such a manner as to bring out his own contention. It must be admitted that no one was so familiar with the operation of this machine as I myself. Had I been consulted or asked to make a demonstration it is quite likely that the court would have put a different construction on my patents.

Issued patents are of course, available to everyone and it is only natural that one inventor will study the other man's patent and benefit by whatever is disclosed, whether it may be helpful of producing results or will show the negative side of a process. I myself have studied other patents and have found many things in them disclosing to me reasons why certain things are detrimental in the process of flotation and in order to understand thoroughly any method of doing a thing one should know the defects and the causes for such defects just as well as the merits. It was by this process of evolution that the flotation process was developed, by no one man, but by quite a number of them, and it is in my opinion unjust that a concern which has purchased a few of the patents issued on such developments should be given a monopoly on a process partially based upon the work of a great many other patentees.

The chemistry of hydro-carbons whether organic or inorganic is very complex and it will take many years before there is a true science of flotation developed, and no one to-day should be permitted to hamper the development of the flotation process by the grant of a monopoly. The flotation process requires improvements and developments, and its progress will be badly retarded by placing it in the hands of a single concern. It has been clearly shown that a great many men have produced decided improvements over the process such as used by the Mineral Separation Company, particularly in later years, and all those contributing to the development of that process should have their fair share in the patent rights, as well as in the financial compensation, and it must be strongly considered that the pub-

lic is, after all, the greatest benefactor of any development which turns present-day waste into money.

Fortunately, the term oil as used in the plaintiff's patents constitutes a limitation, and even if the Separation Company will win finally, this can and will not exclude others from using hydro-carbons that are not oils. I have used chiefly rosin, paraffin and beef-tallow in my early work, and obtained results far superior to results obtained by oils, and I hereby contend that an oil is not at all essential for flotation, but that certain resins and stearates are the essential factors in flotation, and that an oil is merely a liquid containing such resins and stearates and is acting as a carrier for the same. I have been and am concentrating ores without oil, agitation or air, and can demonstrate conclusively that all the essentials claimed in the patents of the plaintiff are absolutely unnecessary for the process of flotation, and if that process can be carried on without any of the features as described by these patents then it is shown conclusively that these patents have not disclosed the basis of flotation. Therefore a basic patent cannot be sustained.

A. SCHWARZ.

Webb City, Mo.

Revision of Our Chemical Statistics

To the Editor of Metallurgical & Chemical Engineering
SIR:—The paper by Bernhard C. Hesse, "Revision of Our Chemical Statistics," which appeared in the Aug. 1 issue of your journal (page 143), has been under discussion by various members of the Division of Mineral Resources. Since it appears from this paper that a concerted movement is on foot to obtain better statistics, it may not be amiss to bring to your attention a few of the problems which must be faced by those who are to be asked to undertake this work, as well as point out a few instances of efforts on the part of the Survey along these lines.

The Survey has long been of the opinion that the Government should give the people of the United States more detailed statistical information concerning the various products made from domestic mineral raw materials as well as information concerning imported products. The Survey has attempted in its annual reports on several metals and non-metals to give this kind of information, as you will perceive by studying the marked copies of several reports inclosed.

The statistics of imports published by the Survey are obtained from the Department of Commerce and are not so complete or diversified as could be wished. It is possible that, if a tariff commission is to work on this problem, it may make the schedules more diversified, depending, of course, on the desires of the country as expressed by that commission.

Concerning the statistics of domestic production, the problem appears more simple in some respects. The Survey has in its mineral resources division a trained force which can collect, and has for some reports collected and published, statistics of the finished products in which these domestic materials reach the market. It is entirely possible, with addition to this force, to publish detailed statistics of all products which are made from the materials upon which the Survey now reports, provided the industries are at that point in their development where they are willing to give the detailed information necessary to compile the statistics. That all industries have not reached that stage in their development is evident to the Survey. To cite a specific instance, the natural mineral pigment producers are not all willing to furnish detailed information from which accurate statistics can be prepared. The same is true of some branches of the chemical industry. On the contrary, many industries have shown

their hearty cooperation in the work along these lines that the Survey has attempted in the past.

Another point which must be borne in mind is this: When materials are made by less than three concerns it is not possible without the consent of all the producers to publish the total production because doing so would disclose the operation of individual firms. This is a difficulty which the Survey has had to face in practically all of its work, for its rule is "never disclose individual production without specific written authorization from the producer."

The mineral resources division of the Survey has always been handicapped by insufficient funds. Its appropriations have been the same for many years, but its work has been greatly increased, particularly in the last two years. Many of the things which it would like to have done have not been possible, because of their cost. The Survey has not been asleep to the possibilities of improvement in its work, but rather it has been unable to do everything that seemed desirable.

I have been frank, as it appears to me that those who advocate better and more diversified statistics should know some of the problems connected with the work of compilation. While the Survey is willing to undertake the added burden of preparing statistics of every product which may be naturally considered as falling within its scope, it would not be possible to do this work successfully until all the industries represented are willing to undertake promptly to supply the confidential detailed information which is necessary for the compilation of accurate statistics.

GEORGE OTIS SMITH.

Director, U. S. Geological Survey.

Washington, D. C.

Chemical Import Statistics

To the Editor of Metallurgical & Chemical Engineering

SIR:—I listened with much interest to the very practical suggestions* made by Dr. Hesse at the meeting in Rumford Hall on Oct. 13, relative to obtaining, through the co-operation of associations of chemists, an extension of the classifications of imports of articles concerning which the chemical industries desire more detailed information than is supplied in the tables now issued by the Department of Commerce. Admirable as Dr. Hesse's plan appears, it seemed to me that it might be worth while to point out that the preparation of a list of statistical designations satisfactory to the practical chemists, while an extremely useful contribution, would be only the first step towards any material increase in the number of titles in the official statistics of chemical imports.

Bureau chiefs in Washington will almost always welcome with enthusiasm the co-operation of technical and commercial organizations when this co-operation is intended to improve the practical value of the reports issued by their respective offices, and will carry into effect any suggestions as far as may be practicable. Usually, however, these suggestions imply a material increase of service, and this means more clerks—and more appropriations.

Appropriation committees of Congress are accustomed to the ardor shown by each bureau or division chief for the development of his particular branch of the government service, and they pare his estimates ruthlessly unless these estimates are supported by something more than his own arguments for the usefulness of his work. Some stronger influence from outside the department must be felt, especially when it is a question of spending money for such apparently academic

work as statistics, the practical value of which is so often doubted by the public.

There must be strong assurances from some influential section that these statistics are worth while and will have a value that justifies Congress in appropriating for whatever additional clerks may be needed in the Bureau of Foreign and Domestic Commerce and the statistical divisions of the customs branches of the Treasury Department. The statement recently printed in the trade journals that a glance at Dr. Norton's census (in proof) of dye imports was worth a million dollars to an American manufacturer of colors, would impress a committee of Congress much more than pages of recommendation from those in charge of such work in Washington. If it can be shown that new industries, or increased profits to our commerce, will result from spending more money on statistics, there will be a likelihood that the appropriations will in time be forthcoming. And the place to present these arguments is before the committees of Congress rather than the executive departments. The latter will usually do all that is possible when the necessary resources are at hand. The time to present such arguments is also important. This is when these matters are actually under consideration, as much of the effect is lost if weeks or months intervene between the filing of recommendations and the meetings of committees. It must be the duty of some one to watch for the right opportunity, with his material prepared in such form that it will carry conviction, not only from the force of the arguments presented, but also from the number and character of the individuals, firms, and associations, or societies represented.

So, too, in the event of a revision of the tariff, much can be accomplished by proper argument before the Ways and Means Committee as to suitable and practical designations. Once a title is imbedded in a tariff law it will appear automatically in the official statistics, and this quite apart from the question of the import duty that may be fixed, or omitted, with respect to the article in question.

A. H. BALDWIN,

Former Chief, Bureau of Foreign and Domestic Commerce, New York City.

Hyde Flotation Suit

Hearing Before Supreme Court

On Oct. 27 the hearing in the Hyde case (Minerals Separation vs. James M. Hyde) came up in the United States Supreme Court in Washington.

The full Supreme Court was sitting, Chief Justice White with the eight associate justices: Justice McKenna, Justice Holmes, Justice Day, Justice Van Devanter, Justice Pitney, Justice McReynolds, Justice Brandeis, and Justice Clarke.

Counsel representing the plaintiff, Minerals Separation, were Henry D. Williams, Wm. Houston Kenyon, Lindley M. Garrison (the ex-Secretary of War), Frederick D. McKinney, John H. Miller and Odell W. McConnell, while those representing the defendant, James M. Hyde, were Walter A. Scott, Thomas F. Sheridan, George L. Wilkinson, K. A. Babbitt, and J. Bruce Kremer.

Mr. John Ballot and Dr. S. Gregory were present of those of Minerals Separation, but Mr. James M. Hyde, the defendant, was not in Washington.

The case did not reach its hearing until 3.30 p. m. on Friday, the 27th, accordingly there was only one hour spent of the plaintiff's argument when a recess until Monday noon was taken.

At the opening a request was made upon behalf of the counsel for both sides that an additional hour be granted each side; that is, to allow each two and a half

*See this Journal, Nov. 1, 1916, Vol. XV, Page 515.

hours instead of the usual hour and a half. The Chief Justice granted this.

It was then stated that it was desirable, in illustration of the argument, that certain metallurgical demonstrations be made in the presence of the court, and that for this purpose a number of metallurgists and experts not members of the bar would have to be present, and permission was asked that they be permitted within the bar. Allowing these demonstrations the Chief Justice demurred, saying that he himself could not see the experiments from the bench, and asked whether it was necessary that these proposed experiments be performed in the court. Counsel for the plaintiff said that it was not necessary, while counsel for the defendant said that it would be satisfactory to have the experiments performed out of court, if the products of the experiments could be brought into court, to which the Chief Justice apparently assented.

Mr. Henry D. Williams then took up the opening of the case for the complainant, going briefly into the history of the case, and in response to inquiry from the Chief Justice explained that there was conflict between the decision¹ of the Appellate Court of the Ninth Judicial District in San Francisco and the decision of certain British courts and the Privy Council of the House of Lords of the British Empire, also with the decision² of Judge Bradford in the Miami case; he explained more or less fully the various points involved in these conflicting opinions.

The Hyde case, as brought to the bar of the Supreme Court, is exceedingly simple as to points involved, since it involves simply the question as to the patentability of the claims of patent 835,120 for less than 1 per cent of oil. In this case before the Supreme Court there is no question of infringement, since the Appellate Court in the decision decreed the patent invalid, maintaining that there was a difference of degree only, and not of effect, in the reduction of the oil from the Cattermole proportions to those of the patent in suit. Mr. Williams devoted the hour to a review of the prior art patents, principally Cattermole, Everson, Kirby, and Froment; with the discussion of the latter he ended the hour. He explained that in Mrs. Everson's descriptive matter of the Everson process, for example, in describing how the materials, these "gobs" of oil and sulphide, were carried over in the upcast with the water, she had used the word "floated" instead of saying carried or washed over, and that the defense had unwarrantably seized upon this word "floated" as a complete disclosure of flotation! He also dwelt, somewhat at length, upon the lack of any disclosure of froth flotation in the prior art patents cited, classing Kirby, Froment, etc., as improvements upon the Elmore "bulk oil" process.

Mr. Williams resumed his argument on Monday noon, using nearly another hour of the allotted time in a discussion of the development made through the experiments of Mr. Higgins and leading to the discovery of the process of the patent in suit; he defied the defense to show that any one of the patents cited by the defendants had ever "arrived at the mill" or attained any practical results whatsoever.

Mr. Walter A. Scott, who made the entire argument for the defense, immediately followed Mr. Williams. Mr. Scott stated that all flotation processes fall into one of three distinct classes: (1) The Elmore bulk oil, or oil buoyancy flotation process; (2) the surface tension, or film or skin flotation process, and (3) the gas-oil flotation process.

He argued that the processes cited in the prior art, which do not fall into either of the first two classes on

account of their quantity of oil (1 ton of oil to 1 ton of ore being the minimum which will give bulk oil flotation), or on account of their nature of manipulation must of necessity fall into the third class, the class of the patent in suit. He argued that the Cattermole process itself was, by the testimony of the experts of the plaintiff, a two-stage process, the first stage being one of more or less violent agitation to thoroughly incorporate the oil in the ore pulp, and the second stage being a slow or rolling process, by which the minute oil-coated particles are rolled and formed into granules.

In support of his argument as to difference in result as due to agitation, Mr. Scott quoted Dr. Liebman, expert for plaintiff (the Minerals Separation), as saying, "I believe that 500 to 600 revolutions are quite sufficient for the Cattermole process. But I believe that at least 1200 revolutions per minute are necessary for the process of the patent in suit in the same apparatus." Mr. Scott also claimed that the word "floated" was properly, correctly and purposely used by Mrs. Everson to describe what actually took place.

Mr. Williams had argued that the effect of the agitation froth process was due to the reduction of the oil to the minute quantity of the process of the patent in suit.

Mr. Scott also pointed out that Judge Bradford had placed absolutely the distinction of the process from the other processes in the definite quantity of oil, in that Judge Bradford had sustained the first and the twelfth claims, and thrown out the ninth, which claimed a "small quantity" of oil, and that there must, therefore, be shown a difference in something more than degree.

In support of Mr. Scott's contention that it was the manipulation and not the definite proportion of oil to ore, and that the patent itself did not actually disclose how to use successfully this definite amount of oil, Mr. Scott quoted at length from the testimony of Mr. Nutter, the American technical manager for Minerals Separation, in his testimony as to how in practice he would determine how to adapt the process to a given ore, in saying: "I would try the following adjustments in my attempt to find proper conditions to produce flotation: (1) I would alter the rate of flow of pulp through the plant; (2) I would alter the speed of agitation; (3) I would alter the quantity, or (4) the kind of oil used; (5) I would alter the dilution of the solution circuit with reference to salts dissolved therein, and (6) I would vary the internal arrangement of the baffles or other diverging devices so as to affect the direction of flow of ore pulp." He thus quoted the plaintiff's own metallurgical manager as concurring in the opinion as to the effect of changes of manipulation, that it was "hard to say in advance, the effects are so various with different oils under different conditions."

This was possibly the climax of Mr. Scott's argument, which was clear and held the attention of the justices throughout. He then digressed to explain somewhat the British litigation, making possibly the impression upon the court that he would question the jurisdiction of the court over the case, since there was no disagreement, as he saw it, between the opinion of the Appellate Court and the British decision.

While the conditions under which one has a right to ask a hearing by the United States Supreme Court are definitely fixed, there is absolutely no restriction upon the court itself, and it can therefore review any decision of any United States court which in its discretion it may desire to review.

Mr. William Houston Kenyon made the closing argument in behalf of the plaintiff in the thirty-five minutes which remained of their time. One might have thought it hardly worth while even to attempt to say anything

¹This Journal, vol. XII, p. 362 (June, 1911).

²This Journal, vol. XV, p. 441 (Oct. 15, 1916).

in so brief a time, by way of summing up a case on which so much could be said. But Mr. Kenyon literally turned the field glass around, and looking into the large end he presented a minute yet perfectly clear picture of the entire field. Not only did he review what previous counsel had said, as to the discovery of the process and its applicability, but he contrasted each of the prior art processes quoted by the defendant with the results of the process in suit, also claiming, as had Mr. Williams, that the prior art processes had produced no practical results and that there was nothing in the record in the case to show that their agitation froth had ever been produced or could be produced by those processes in the actual art, although admitting that in laboratory experiments "oil froths" could be obtained which were indistinguishable in appearance from the "air froths" of the patents in suit. He also found time to cite various decisions of the Supreme Court on parallel cases, and actually closed a moment or two before his thirty-five minutes had expired.

There was a very unusual and interesting feature in connection with this case. The Chief Justice announced, during the course of Mr. Scott's argument, that the members of the court would come to the Capitol Building at 10.30 on Wednesday morning to witness such demonstrations illustrative of argument as it might be necessary to make, but that attorneys were expected to make no argument during the performance of the demonstrations, only making such explanation as would be necessary to make clear what each demonstration was intended to represent.

The necessary apparatus was therefore assembled within the bar of the Supreme Court.

This demonstration, however, was not open to the public, only those connected with the case being expected to be present. Each side presented what it conceived as the apparatus of the prior art, the plaintiff to show the utter futility of the prior art processes, the defendant to show that there was no distinction, which was observable, between using the proportions of oil of the patent in suit and the use of larger quantities, even up to Kirby's 25 per cent of kerosene.

The results obtained in the presence of the members of the court were apparently so utterly contradictory that the Chief Justice requested that the plaintiff and defendant explain to the court how each accounted for the difference; an additional hour was granted for the purpose, half an hour for each side. The explanations were made by Mr. Williams and Mr. Scott for plaintiff and defendant respectively, Mr. Williams dividing his half hour into two, an opening and closing argument.

The argument of Mr. Williams was chiefly that the apparently successful results with quantities of oil in excess of those of the patent in suit were deceptive, that they were not in reality obtained with the air froths of the patent in suit, that they were mere laboratory tricks, possible only in the laboratory and having no utility whatever in the art.

Mr. Scott, on the other hand, contended that in performing the experiments, defendant had complied absolutely with the disclosures of the patents represented; that the patent in suit disclosed no greater violence of agitation than the prior art patents, the wording of which patents was possibly even more descriptive of violence of agitation than the patent in suit.

While this extra hour had been taken by the Chief Justice to discuss in court the difference of results of the experiments which had just been witnessed, it is remarkable that in this discussion the whole question of the suit was narrowed down to one point, and that is the point as to whether these experiments of defendant actually did or did not represent operations which it

would be possible, apart from the question of mere economy, to carry out upon a commercial scale in an actually operating plant.

Mr. Scott could not point to any testimony in the record of the Hyde case as to the use, upon an actual working scale, of these larger quantities of oil, although in reply to a question of one of the Associate Justices he said that there was such testimony in a parallel suit.

Mr. Williams, in his final closing of the case, referred to the testimony introduced by plaintiff as to the use of larger quantities of oil in plants of commercial size and stated that they got no results, that their attempts to use such larger quantities of oil were "absolute failures."

* * *

From the above brief outline it is seen that apparently the plaintiff took definitely the position that the process of the patent in suit was the result of the reduced quantity of oil. In this connection we would call attention to our comments on Judge Bradford's decision in the Miami case, to the effect that imprecudged investigators, mostly professors in our technical schools, who have studied flotation phenomena, have found no reason for discussing relative quantities of oil in their explanations of the causes of flotation. Is this a sin of omission on their part or is this distinction between different quantities of oil more of legal than engineering importance?

But here is the controlling patent, 835,120, for proportions of oil less than 1 per cent of the ore, before the deciding tribunal of the country, the United States Supreme Court, which court in its decision can consider only the evidence which was introduced in the Hyde record. The decision of Judge Bradford may be considered, but not the testimony contained in the record of the Miami case nor the great mass of literature on technical research which has appeared since the Miami trial.

Again, we might repeat what we had to say in connection with Judge Bradford's decision on the unsatisfactory basis of our whole patent law procedure.

Proposed Gasoline Specifications of Bureau of Mines

In direct response to the request of the General Supply Committee of the executive departments of the Federal Government in the District of Columbia for specifications to govern the purchase of gasoline in the District, the Bureau of Mines, Van H. Manning, Director, has prepared tentative specifications and has sent copies of them to the refiners, automobile engineers, jobbers, and other men prominent in the industry, with the request that the draft be criticized in order that when the specifications are finally issued they will be fair alike to the refiner and consumer. It is hoped that as a result of the consensus of opinion of all the interested parties specifications can be prepared that will be of value not only to the Federal Government in the District of Columbia, but to the entire public using gasoline for fuel purposes.

There is at the present time a considerable difference as to the grading of gasolines. The Bureau has attempted to grade gasolines, bearing in mind the principal motor purposes for which gasoline is used.

In the tentative specifications, the specific gravity test has been eliminated, as it is generally considered that specific gravity alone means little and is entirely inadequate, since it may give a high rating to a poor gasoline and a low rating to a good one. At present, the general tendency is to either specify tests which are unreliable, or else make requirements which are

unreasonably severe. Many buyers believe that only straight refinery gasoline, and not casinghead gasoline and cracked products, are desirable, and the test they require discriminates against a large portion of our market supply of gasoline.

The basic property which determines the grade and usefulness of a gasoline is volatility. It is not, however, a property whose influence may be stated concisely and in a few words. It is, of course, advantageous to have motor fuel vaporize easily. It is obvious that gasoline is not gasoline if it cannot be converted into an explosive gaseous mixture under conditions existing in the engine. These simple considerations would lead to the conclusion that the desirable product is one having a fairly high initial boiling point and a low end point. Here again, however, it is necessary to take account of further considerations which complicate the matter. The first is that a gasoline of narrow and selected boiling range is bound to be exceedingly expensive. In addition, it is not an unmixed advantage to have such a product. A high initial boiling point tends to make the engine in which such a product is used difficult to start in cold weather. It is also a question as to whether or not the low end point is an unmixed advantage. Some of the refiners of so-called blended products claim that the presence of the heavier naphthas causes the explosion in the engine cylinder to take place more slowly than in the case of lighter gasoline. The piston head is drawn through the same distance and the same power is developed, but the force is applied with a gradual push rather than with explosive violence.

It is claimed that this sort of action lessens the strain on the engine and actually tends toward greater power production.

These are claims for which as yet no conclusive experimental proof seems available. They seem, however, entirely plausible and are more than likely to receive credence because such products are bound to be used on account of cheapness.

In summing up the desirability of various degrees of volatility, it appears that it is desirable to have a certain percentage of fairly low-boiling constituents so that engines may start readily, but undesirable that such constituents should be present in too large proportion, on account of the resulting increased possibility of loss through evaporation and of accidental ignition and explosion. A reasonably low-end point is desirable in order to insure complete vaporization, but it makes the gasoline expensive. In addition, if it is possible to utilize high-end-point gasolines efficiently, it seems conceivably possible to develop maximum power with less strain on the engine. For these reasons, the end point should be as high as is possible, without exceeding a limit set by the ability of the engine to atomize and vaporize the gasoline properly. It is, of course, impossible to set limits which will meet all needs, but figures have been chosen which general use seems to indicate as most practical.

The analytical methods used for the testing of gasoline are of fairly recent development, but no adequate description of them appears to be available. Some of the tests employed are not standardized, and there are substantial differences in the methods by which they are conducted in various laboratories. There seems also to be a lack of knowledge regarding the practical interpretation of results obtained by analysis. The tendency is to overemphasize some particular figure. Formerly specific gravity was considered the complete index of the qualities of gasoline. At present a similar overemphasis is placed on the so-called "end point" of the Engler distillation. One of the chief objects of the

proposed gasoline specifications is to indicate rationally methods of interpreting the analytical results.

At the present time there are sold in the market several grades of gasoline, these generally being classified according to their specific gravity, although the distinctive quality is that of volatility, the gasolines with low specific gravity and generally with low boiling range selling for the highest prices. Heavier grades are cheaper, and if properly used are capable of developing more power per unit volume than are the lighter gasolines. The Bureau of Mines has considered it advisable to divide gasoline into three classes, to be designated according to the maximum temperature limit (in degrees Centigrade) below which 90 or 95 per cent by volume must distill. Keeping in mind that the high-grade gasoline is to be used for special purposes, such as for aeroplanes, etc., and should include products of the type now sold in the Eastern market as of 70° Baumé or over. The middle grade is to be used for automobiles of a design of say, two years ago, and is represented by the type of gasoline now sold in the Eastern market, which ranges from 65 to 70° Baumé. The third grade, represented by the gasolines now sold in the Eastern market as around 60° Baumé gravity, is being used satisfactorily in up-to-date automobile engines. It is, of course, realized that the automobile engine has been improved so that it can use a heavier grade of fuel than was possible a few years ago.

The essentially desirable properties of gasoline may be stated briefly as follows:

(1) Neither the gasoline nor its products of combustion should have a strong or markedly disagreeable odor, this being objectionable to users of automobiles.

(2) The gasoline should be free from matter which is not hydro-carbon, such as water, sediment, acid, etc.

(3) The gasoline should be free from bodies which either originally or after combustion attack the metal composing the engine. Unremoved acid in refining and excessive sulphur content fall under this head.

(4) The gasoline should not contain excessive percentages of unsaturated or aromatic hydrocarbons, since some evidence is at hand which indicates that there may be limits in the ability of motors, as at present constructed and adjusted, to utilize these products.

(5) The gasoline should not contain too high a percentage of very volatile products which tend toward high evaporation losses and excessive danger in handling and storage.

(6) The gasoline should not contain any considerable percentages of heavy or non-volatile constituents which prevent the atomization into engine cylinders of a mixture which can be completely burned.

The above stated requirements are simple in principle and are almost axiomatic. The only problem is to fix limits, defined by experimental practice, which shall satisfy the desirable conditions.

There are at present on the market types of gasolines produced by several general refining methods. These may be classified as follows:

1. "Straight" refinery gasoline.
2. Blended casinghead gasoline.
3. Cracked and blended gasoline.

"STRAIGHT" REFINERY GASOLINES

"Straight" refinery gasolines are produced by methods which vary somewhat in different parts of the country, but are in general similar. Crude oil is distilled in a fire still and a cut made when the gravity of the product reaches some predetermined mark. The so-called crude naphtha or benzine is acid refined and then steam-distilled. In some cases several products of different ranges of volatility are produced, in others the

steam distillation simply effects a separation from less volatile bottoms which go into the burning oil stock.

"Straight" refinery gasolines are characterized by low content of unsaturated and aromatic hydrocarbons, and by a distillation range which is free from marked irregularities.

BLENDING CASINGHEAD GASOLINES

A product which has come on the market during the last few years is so-called casinghead gasoline which is produced from "wet" natural gas by processes of compression or absorption. "Straight" casinghead gasoline is too volatile for general use, and before being put on the market is blended with a sufficient proportion of heavy naphtha to produce a mixture which is both safe for use and moderately cheap. Blended casinghead gasolines are generally characterized by a volatility range showing considerable percentages of constituents boiling at both low and high temperature, but a deficiency of intermediate products. In some cases, however, the blending is done in such a manner that it is difficult to detect the natural-gas gasoline. This is when it is used in moderately small proportion to lighten and to make more volatile gasoline which has a boiling range approximately the same as that satisfactory for motor purposes.

As far as chemical properties are concerned casinghead gasoline seems to be identical with the "straight" refinery product. The characteristic properties are, therefore, wholly due to the details of blending.

CRACKED OR SYNTHETIC GASOLINE

One of the important factors in the present gasoline market is the production of cracked or synthetic gasolines. These are being marketed in enormous quantities largely, if not altogether, in the form of blends with "straight" refinery and casinghead gasoline.

Cracked gasolines are similar in physical properties to "straight" refinery products, but are different chemically in that they contain varying percentages of unsaturated and aromatic constituents. It has been demonstrated that these constituents do not decrease the value of a gasoline, if they are not present in too great proportion. It is still an open question whether or not motor fuel containing very high percentages of unsaturated compounds can be utilized in the same way as the "straight" refinery products.

Attention is also called to the fact that refiners are today marketing gasoline containing considerable percentages of unsaturated compound, and these products are being satisfactorily used by the public.

The Iron and Steel Market

The iron and steel trade is giving another exhibition of its ability to show kaleidoscopic changes. The outstanding feature of the general market, until quite recently, was simply the large amount by which steel prices advanced and the pressure that was exerted upon mills for deliveries. Pig iron attracted attention chiefly by reason of the fact that it had failed to advance by anything like a proportionate amount. With few exceptions finished steel products advanced simply in keeping with unfinished steel, so that the steel-making capacity was clearly seen as "the thin neck of the bottle."

The condition has now changed. Finished steel products have continued to advance, but the outstanding feature in the situation is the rapid advance in pig iron and the scarcity of coke.

A weighted average shows that pig iron has advanced about \$5.20 in the four weeks ending at this writing, while almost one-half of this advance has

occurred within the past week. The advance in the four weeks is almost equal to the total advance that had previously occurred, from the low point at the beginning of 1915.

The advance in pig iron is not fully understood, as to its causes and ultimate extent. About all that can be said, in general, is that it furnishes a fresh complication in the iron and steel situation.

Another change, kaleidoscopic in character, is that while hitherto the chief interest, as to tonnage production, has been in the physical capacity of the productive units and the rate at which new units might be completed, and the prospective supply of labor, the question engaging the most serious attention now is whether the transportation system of the country will be able to furnish adequate service for the continued operation of the productive capacity at its own physical limit.

Car Shortage

Car shortages have been steadily developing. At first the shortages were confined almost entirely to the coal mines. With an abnormally heavy demand for coal the mines were so poorly provided with cars that their output was decreased and shipments against regular contracts became less than consumers' requirements and less than the contracts called for. The steel mills and some other consumers bid for coal in the open market and prices for spot coal advanced to three or four prices. The highest price for Pittsburgh district mine-run, per net ton at mine, was about \$6 for steam and about \$6.50 for gas, while altogether a very considerable tonnage was sold at \$5 and higher for steam, of \$5.50 and higher for gas. Prices involved in long-term contracts are \$1.25 to \$1.35 and on annual contracts \$1.30 to \$1.50.

At the same time slight shortages of cars developed at Connellsville coke works, but in general the coke works were much better supplied than the coal mines. More recently car shortages for the shipment of finished steel have become serious, and while they have not thus far resulted in any widespread congestion of steel awaiting shipment from mill it has been only by careful management that congestion has been avoided. With the majority of finished steel products there are no facilities at mill for the storage of any considerable tonnage. In the case of tin plate, sheets, wire products and pipe large warehouse facilities are part of the regular equipment, but even then the double handling is expensive, and cannot conveniently be compassed at this time when labor is so scarce. In bars, plates and shapes the storage facilities are relatively limited. Plates are the most awkward commodity, and it is for plates that there is the heaviest demand.

A very tense condition has resulted, the flow of raw, semi-finished and finished material being conducted with much difficulty. This condition has arisen under very favorable weather conditions, while it is practically certain that bad weather will come within a very few weeks. Even when the railroads are working at their best the first cold snap slows down their operations. At present the railroads are working under high tension, with insufficient motive power and with many locomotives kept out of repair shop through no merit of their own, but because they cannot be spared. In cold weather they may not go at all. It is felt in the steel industry that there is a strong balance of probability that cold weather will result in a general railroad blockade of such extent as to curtail the production of iron and steel, and production may be curtailed all along the line.

October outputs were exceptionally good, partly because the weather was, as usual in October, especially favorable, and partly because mill managers and heads of departments have gotten into the habit of grooming their equipment and arranging matters generally so as to make a record in October. The Carnegie Steel Company produced 970,000 gross tons of ingots in the month, a new record, its objective point having been 1,000,000 tons. Many mills made new records, which may be heard of when there is time to discuss such trivial matters. The production of pig iron in the industry as a whole averaged 41,700,000 tons per annum, against only a 38,100,000-ton rate in August and a previous maximum rate of 39,800,000 tons, last May. It is doubtful whether a 40,000,000-ton rate can be averaged in the remainder of the year.

Pig Iron and Steel

At this writing basic pig iron at valley furnaces is \$25 and Bessemer \$29, against \$12.50 and \$13.60 at the low points early in 1915. Billets are \$50 to \$55, against a trifle less than \$19 at the low point. Thus pig iron has much room for an advance if there is pressure for pig iron to keep the steel works in full operation. Apart from transportation difficulties the most serious menace to full pig-iron production is the coke situation. Connellsville furnace coke, for which there are contracts in force, for the present half-year, at \$2.25 to \$2.75 per net ton, f.o.b. ovens, has brought \$7 to \$8 during the past few weeks, for spot shipment, the price representing the urgency of some consumers for coke in addition to that supplied on their contracts. The merchant furnaces, with pig iron to deliver under contract at a profit of \$2 to \$3 with their raw materials at contract prices, cannot afford to pay such prices, while to the steel mill the price is no deterrent.

Finished steel products continue to show an advancing tendency. Regular mill prices are supposed to be 2.70c. on bars, 2.80c. on shapes and 3.25c. on plates, but these prices have become largely nominal. In the first half of November wire products have been regularly advanced \$3 a ton and sheets have advanced about \$5 a ton. Steel boiler tubes have been advanced two points or about \$4 a ton, and lap-weld iron and steel pipe has been advanced one point. The American Sheet & Tin Plate Company on Nov. 6 withdrew from the tin-plate market, being practically sold up. It was only on Oct. 12 that it entered the market, for the first quarter of 1917 in the case of jobbers, and for the first half in the case of manufacturing consumers.

The Steel Corporation's unfilled obligations at the end of October, as announced on Nov. 10, amounted to 10,015,260 tons, a new record. The increase during October was 492,676 tons, the largest increase for a month since last April. The increase amounted to about 39 per cent of normal capacity for the month, while shipments may be estimated at 106 per cent of normal capacity, indicating bookings at 145 per cent of capacity. The bookings were largely in sheets and tin plates, in which business for several months' delivery was crowded into the one month, while there was also a large volume of car and ship material. After several months of very light buying the railroads contracted for about 20,000 freight cars in September and about 32,000 in October.

Non-Ferrous Metal Market

Nov. 10.—The election brought most of the metal markets to a standstill, temporarily, awaiting the result. Copper is higher with a scarcity of metal existing. Tin is firm with little business doing. Lead

is quiet owing to the election uncertainty. Spelter is higher in an unsettled but active market.

Copper.—The market is in a strong position with offerings very small for November and December delivery. A rumor is abroad that England is in the market for 200,000,000 lb. for shipment over the second half of 1917 but no confirmation of the report has come yet. The demand for home consumption is good, with spot electrolytic at 31.00 cents. First quarter is offered at 29.00 to 29.50 and second quarter at 28.50 to 29.00. According to the American Metal Market Report there is no large inquiry for 1916 shipment that cannot be filled from resale lots or from consumer's offerings. Exports for October were 32,712 tons. Exports for ten months ending Oct. 31, were 277,930 tons, which compares with 276,344 tons exported in 1915.

Tin.—The tin market remains firm in spite of a very small buying movement. Spot Straits tin is held at 43.00 cents. There is not much future tin offered, on account of the reported strong market abroad, sellers preferring to wait. The tin situation as it stands at present appears to be that there is a large demand and the supply is not sufficient to take care of it. Arrivals so far this month are only 300 tons but there is over 4000 tons afloat and due by Nov. 20 on various steamers. Arrivals in October were 2655 tons, considerably below the average.

Lead.—The lead market is dull both here and abroad, with the Trust price still 7.00 cents at New York for early deliveries. Independents ask 7.12½. Exports so far this month are 678 tons. Exports in October were 4609 tons.

Spelter.—Prices are higher and have risen steadily the last few days. An unsettled condition prevailed during the election period and little business was done. For November delivery 11.25c. is asked. For December 11.12½c. is asked. First quarter is quoted at 10.75 to 11.00 and second quarter at 10.50. Exports up to No. 8 were 2861 tons.

Other Metals.—Silver is up to 71½, which is the highest price since last May. Magnesium is held at \$3.50 per lb., electrolytic nickel at 55 cents, cadmium at \$1.50 per lb. Quicksilver is quoted at \$80.00 per flask and platinum at \$95.00 per oz. Aluminum is offered at 66.00 cents for No. 1 virgin metal. Antimony is quoted at 12.87½ to 13.12½.

Coming Meetings and Events

American Mining Congress, Hotel LaSalle, Chicago, Nov. 13-18.

Society of Chemical Industry, New York Section, New York, Nov. 24.

American Society of Mechanical Engineers, New York, Dec. 5-8.

American Association for the Advancement of Science meets with American Chemical Society and also with the four national engineering societies represented at the Engineering Societies Building, New York, Christmas week, 1916.

American Institute of Chemical Engineers, New York, Jan. 10-13, 1917.

Chemistry and the Gas Industry.—The joint meeting of the New York Section of the American Electrochemical Society and of the Illuminating Engineering Society on Nov. 9 was very interesting. Two papers were presented, one by W. R. Addicks on gas standards, the other by Elmer L. Knoedler on the chemistry of the new flexible mantle. The papers elicited an interesting discussion. W. Greeley Hoyt presided. An account of the proceedings and of the papers and discussions is reserved for our next issue.

The Chemist in Public Service

A meeting of the New York section of the American Chemical Society was held on Friday evening, Nov. 10, at the Chemists' Club, at which the general subject of "The Chemist in Public Service" was discussed in four very interesting papers. It was the consensus of opinion that the highest ability is required in Government, State and City service, but that the compensations provided are inadequate and do not attract the best men.

Prof. CHARLES A. BEARD of Columbia University, gave his views on the general problem of public service training. He said there are nearly 2,000,000 employees in the service of the Government, States, and Municipalities, with between 80,000 and 90,000 in New York City. The great increase in the number of our Government employees has been caused by our enormous industrial activity. Professor Beard thinks the most serious problem is to educate the public into realizing that Government employees must be trained scientific men.

Prof. FREDERICK E. BREITHUT of the College of the City of New York, presented some very interesting tables gathered from authoritative sources at Washington, showing the number, titles and compensation received by chemists in the Federal Service. Similar tables for State and City service were presented. In the Federal service there are 716 chemists with 71 distinct titles which cost the Government \$1,500,000 per year. Seventy-five per cent of all chemists in Federal State and City service get salaries ranging from \$1,000 to \$2,500. Professor Breithut recommended that a committee be appointed by the society to determine the status and compensation of the chemist in public service in order to raise the standard.

Dr. OTTO H. KLEIN, director of the Central Testing Laboratory, New York City, gave an interesting outline of the work of his laboratory in testing materials purchased by the city. He was in favor of more adequate compensation.

Dr. HARVEY W. WILEY gave a very interesting and witty talk, in which he recited some of his experiences in the Bureau of Chemistry of the Department of Agriculture, of which he was one of the first four members and was chief chemist for many years. He said there are three kinds of chemists in public service, viz., the routine chemist, the research chemist, and the executive chemist. Research is an important part of the Government chemists' work.

The Western Metallurgical Field

Mills

The Hartford Mining Co. is remodeling a 300-ton mill, formerly located near the Empire Zinc Co.'s ground near Galena, Mo. The contract for the remodeling of the mill has been let and work is to start immediately. The mill will be made modern throughout with well-equipped jigs and sludge tables to handle the fine ore. The three shafts will be connected to the mill hopper by incline tramways. A huge hopper will be employed to feed dirt to the mill. This new mill will have a daily capacity of 400 tons. The same company also has producing mines at Cave Springs and operates a 300-ton mill in this locality which in the last week of September turned in 133,460 pounds of blende and 15,200 pounds of lead.

The Eaglewood Mining Co., located near Bellville, Mo., is erecting a new 250-ton mill to handle rich dirt. The mill will be of the most modern type and it is expected will start operation on the first of November.

Recently the mill of the Prince Consolidated was

completed. The mill is located a mile and one-half from the station of Panaca, Nev. It is being built on the old smelter site at the former camp of Bullionville. A description of this mill was given by C. F. Sherwood in the Salt Lake Mining Review, an extract of which may prove of interest. The mill has in view the treatment of the Bullionville and Dry Valley tailings, which are situated approximately half a mile from the station of Panaca. The tailings are over 40 years old and are the results from old mining practice. Most of these tailings have been retreated by amalgamation and cyanidation. The Dry Valley tailings are identical with the Bullionville tailings and are shipped to the mill. All these tailings are highly siliceous and entirely oxidized. The values contained are: Lead, 8.2 per cent; silver, 11 ounces, and gold to the extent of \$1.40. Due to the fact that the lead is contained as carbonate and the silver as chloride, a gravity separation of such an ore would give low results. The most economical method for concentration was found to be the sulphidizing of the lead carbonate with a sulphide film by means of sodium sulphide and then floating the lead off.

The Mill Flow.—By means of a 30 x 10-ft. thickener, the tailings are collected at the head of the mill. The thickener is supplied from the pit by means of a 2-in. compound sand and slime pump. The thickener at the same time acts as a regulator for the supply of tailings to the mill. The underflow from the thickener enters a 5 x 16-ft. tube mill, which contains a load of 6 tons of manganoid spheres. The discharge from the tube mill flows to two 14 x 6-ft. underfed agitators. These latter have proved unsuccessful due to the large amount of sand treated and are being replaced by mechanical agitators. The sodium sulphide solution is added to the pulp at the discharge from the tube mill, and the active sulphidizing lasts at least 30 minutes after leaving the agitators. From here the pulp passes to an elevator, where the oil is added, and is emptied into two 4 x 18½-ft. pachuca tanks, which operate under a pressure of 30 pounds. The pachuca tanks act as emulsifiers. These tanks discharge directly into a series of six roughing cells, the concentrates being broken up by a water spray and a belt elevator and are cleaned in one cleaning cell. The tailings are returned to the feed of the pachuca. The concentrates are thickened in a 16-ft. thickener and filtered by means of an 8 x 6-ft. continuous filter. The tailings from the roughing operations are classified, the slime overflow from the classifier being pumped to a 2 x 8-ft. pachuca tank, where a small amount of oil is added and refootation takes place. The regular concentrates from this operation are cleaned in a half size cleaning cell; concentrates from this cell joining the rougher concentrates from the first series, the tailings from the cleaner returning to the small pachuca for retreatment. The tailings from the second series rougher are sent to waste. The discharge from the classifiers is tabled on four slime tables, the concentrates going to the concentrate thickener running also on the clean flotation concentrates. The middlings are returned to the head end of the mill for retreatment and the tailings go to waste.

Nickel

In the past, the main nickel supply came to this country from the Sudbury district of Canada. From a metallurgical standpoint it is therefore interesting to know that nickel-bearing ore deposits of considerable extent have been located in California. According to Bulletin 640-B, U. S. Geol. Survey, 1916, this nickel deposit is the property of the Friday Copper

Mining Co., located about four miles south of Julian, a village 60 miles northeast of San Diego, Cal.

The ore of the Friday property is mainly pyrrhotite, but also contains pyrite, chalcopyrite and an iron-nickel sulphide. The ore is accompanied by small amounts of amphibole and a carbonate, which in all probability is calcite. The pyrrhotite in this ore possesses an unusually perfect cleavage, a parting of which shows that some of the individual crystals have a diameter of 2 in. The pyrite forms a network through the ore and is present to an extent exceeding 10 per cent. Much smaller in amount is the chalcopyrite and a smoothly polished white mineral, which on analysis proved it to be an iron-nickel sulphide, the crystalline form of which could not be accurately determined. The mineral is not pentlandite, as it does not possess the characteristic brownish-yellow tint. As it is free from arsenic it cannot be gersdorffite. In all probability the mineral is polydymite Ni_3S_4 with part of the nickel replaced by iron, giving the formula Ni_2FeS_4 .

The cupriferous and nickeliferous sulphides occur, for the most part, in contact with one another, forming irregular bodies about 5 millimeters in maximum diameter. The supposed polydymite also forms small veins, which cut the pyrrhotite but not the pyrite. This phenomenon suggests that the cupriferous and nickeliferous sulphides are very nearly contemporaneous and older than the pyrrhotite, while the pyrite undoubtedly is the latest of the sulphides.

If these deposits occur in large enough amounts, and if the average nickel content justifies an economical treatment, there will be an opportunity given to the metallurgist to apply the newest methods of concentration for a satisfactory separation of the various sulphides from each other.

Current News and Notes

Production of Primary Spelter, Jan. 1 to June 30, 1916.—The table below is taken from the Press Bulletin of the U. S. Geological Survey, No. 285, Aug. 16, 1916, and gives the statistics from 1912 to 1916 by six-month periods:

Another table of interest is the one on page 6 in the

same bulletin, giving the active zinc smelters in the United States and their capacity for 1916.

Contract Reform in the Glass Industry.—A committee of the National Glass Distributors' Association recently held a meeting in Pittsburgh with manufacturers of plate, window and wire glass for the purpose of discussing a proposed new contract similar to that adopted by the National Association of Sheet and Tinplate Manufacturers, which eliminates conditions or provisions guaranteeing prices against market declines. A further investigation will be made before taking any definite action.

The **Milwaukee Engineers' Club**, which includes in its membership members of the American Society of Mechanical Engineers, American Institute of Electrical Engineers and American Chemical Society, held a meeting recently in the new engineering building of the Federal Rubber Company, Cudahy, Wisconsin. Mr. L. J. D. Healy, chief chemist of the company, read a paper on "The Growing and Gathering of Rubber Latex."

Welfare and Efficiency Conferences—The Fourth Annual Welfare and Efficiency Conference of the State of Pennsylvania will be held in the House of Representatives at Harrisburg, on November 21, 22 and 23. The meetings are held for the purpose of improving relations between employers and employees, and to discuss safety and welfare work. The arrangements are in the hands of the Department of Labor and Industry.

Alcohol.—An order for 30,000,000 gallons of alcohol was reported to have been received the first week in November by the United States Industrial Alcohol Co. from a large powder manufacturer. The order involves practically \$10,000,000. The large domestic demand for alcohol has greatly curtailed our exports, and the shortage has been keenly felt abroad.

The **Nordberg Mfg. Co.**, of Milwaukee, Wis., announces the appointment of Mr. H. W. Dow as sales manager. Mr. Dow has been associated with the Nordberg Mfg. Co. in the engineering and sales departments for 12 years. The Nordberg Mfg. Co. build steam and electric hoists, Corliss engines, poppet valve engines, uniflow engines, air compressors, oil engines and the Nordberg-Carels Diesel engines.

SPELTER STATISTICS, 1912-1916, BY SIX-MONTH PERIODS (In Tons of 2,000 Pounds)

	1912		1913		1914		1915		1916
	First Half	Last Half	First Half	Last Half	First Half	Last Half	First Half	Last Half	First Half
Supply:									
Stock at beginning	9,081	6,414	4,522	21,856	40,650	64,039	20,095	5,884	14,253
Production—									
From domestic ore	159,952	163,955	171,135	166,117	171,496	171,922	207,634	250,501	267,696
From foreign ore	6,544	8,355	9,078	346	3,562	6,060	8,808	22,486	48,756
Imports	3,053	8,062	5,533	567	506	874	489	415	404
Total available	178,630	186,786	190,268	188,886	216,223	242,404	237,116	279,286	331,109
Withdrawn:									
Foreign exports	7,331	174	8,724	4,672	2,048	8,513	5,959	8,016	20,197
Domestic exports	5,839	795	6,615	1,168	824	63,983	64,368	54,235	58,007
Stock at close	6,111	4,522	21,856	40,650	64,039	20,095	5,884	14,253	23,879
Total withdrawn	19,584	5,491	37,195	46,490	66,911	92,591	76,211	76,504	102,083
Apparent consumption	159,046	181,295	153,073	132,387	149,312	149,813	160,905	202,782	229,086
Spelter made in:									
Illinois	44,224	44,173	53,524	53,130	62,062	65,884	74,982	81,976	90,082
Kansas	52,485	48,619	42,645	31,461	23,737	20,773	35,247	66,176	74,392
Oklahoma	36,010	40,915	43,253	30,961	45,443	45,921	51,172	58,436	74,308
All other States	33,777	38,603	40,791	41,911	43,816	45,410	55,131	63,799	78,480
	166,496	172,310	180,213	166,463	175,058	177,991	216,532	272,987	316,452
Zinc ore imported:									
Zinc content	27,649	16,891	19,994	11,422	9,052	22,910	60,683	92,160	231,815
Zinc ore exported	12,228	5,159	9,204	4,293	2,919	9,183	23,997	33,672	93,907
	15,421	11,732	10,790	7,129	6,133	13,727	36,686	58,488	137,908

* Primary spelter, which is produced directly from ore, is here distinguished from "secondary spelter," which is obtained by refining zinc ashes, drosses, and old metals.

Guayule and Industrial Preparedness

By Andrew H. King

Every patriotic American believes in preparedness, both for war and for peace. We realize that the nation best prepared for peace is also best prepared for war. As has been said, modern warfare is fought by machinists and chemists, not at the front, but in the factories. Broadly speaking then, war of nations is a contest between their industries.

Industrial preparedness means simply the co-ordination and co-operation of American industries. It does not mean consolidation, but simply friendly, mutual assistance. There will be no stock jobbing profits to distribute. Remarkable as it seems, the idea is to raise our industries to the highest efficiency possible, and what is more remarkable, to increase the quality of the products. The more nearly a country is self-contained and self-supporting, the safer it is from invasion, and the stronger it is in war. Germany is an extraordinary example of industrial preparedness. She has been cursed with militarism, but blessed by industrialism. The first drew her into war, and the second will get her out of it. For two years she has been practically shut off from the rest of the world, yet she has supported herself and kept the war beyond her borders.

True industrial preparedness demands a plentiful supply of all necessary raw materials. But two have furnished real problems in Germany. Copper had to be requisitioned from all parts of the empire. Even the bells had to be melted down. All this material was a potential resource and could be recovered. Rubber was a different proposition, since reclaiming always decreases the quality. While it is probable that a considerable supply of crude rubber was laid by in anticipation of the blockade, it is quite certain that this quantity proved insufficient, and that a decided rubber famine now prevails in Germany. By latest accounts, fine Para is selling for about \$15 per pound in Berlin. We are paying a little less than 90 cents for the same rubber.

I hardly think it necessary to outline the part rubber plays in modern warfare, but I will mention a few of the most important instances. The part that motor trucks play is well known, they have taken the place formerly occupied by endless mule teams. The ammunition, food, and other necessities are all carried from the base of supplies to the front by trucks. Huge motor lorries carry whole companies of men to threatened points, in an infinitely shorter space of time than they could possibly "double quick" it. Wherever we have motor conveyances we must have rubber tires. Safety, speed, and comfort demand it.

Then the men in the trenches must be protected against the weather. They must sometimes stand for hours waist deep in water. It has been said that the rigors of army life killed more men than the bullets in our Civil War. A great civilian army cannot be expected to withstand such hardships. England knows this, and her soldiers are protected by suitable rubber coats and capes, and they wear high hip boots in the trenches. The underground bomb-proof shelters are sometimes lined with regular ground sheets. These are squares of rubber coated cloth which the soldiers place on the floor of their tents to keep out the dampness.

The list can be prolonged almost indefinitely. When a country does not have enough rubber to properly care for her men at the front, what must be the condition of the people left at home? What will they do for fire hose, rubber gloves, etc.? Their need will be just as great, if not greater, than that of the soldiers.

"Safety First," which is but another name for "Industrial Preparedness," demands that we make such a

predicament impossible. A recent poll of the country has shown that our rubber companies are quite capable of handling any emergency which may arise, *provided* their supply of crude rubber be not interfered with. Such interference would depend considerably on whom our enemies might be. Under present plans outlined by the last Congress, our navy is to be made second-best in the world. It is not considered worth the effort to try to surpass Great Britain. It is believed that there will never again be war between English speaking nations. Nevertheless, such a calamity is quite possible, and should this ever happen we would be barred from the seas just as effectively as is Germany at present. In any case, ships bearing rubber to our shores would be in constant danger, and without doubt the supply would be considerably decreased, if not completely cut off.

The best way to prevent such a situation is to build up in this country a strong, profitable, crude rubber business; which would be a valuable resource, a source of protection in time of war, and a source of wealth in time of peace. It would require no special protective duties to give it a start, but only brains and capital.

It has been suggested at numerous times that the Philippine Islands is a suitable location for an American plantation industry. Conditions there are quite favorable, but it would still mean ocean transportation, which, as has been stated, would be dangerous. Besides, some rather thoughtless parties in Congress seem about ready to set the Islands adrift. They seem to forget that American lives and money were spent in acquiring them, and now that the American people are soon to reap what they have sown, they bring up the old cry of imperialism and say "Set them free!" This country needs a tropical colony and now that the Philippine Islands are becoming a safe place for a white man to live in, they should be developed. But until the matter is definitely decided, it is not a good policy to invest much American capital there.

We have a good example of such a situation in Mexico, where some billions of dollars have been invested. How much of this sum still remains we do not know, but we are quite certain that it is earning next to nothing, and that means loss enough. Our statesmen and our capitalists should learn a lesson from the British and always, with rare exception, keep American money under the American flag. This is but another instance of "Safety First."

In 1915 the world's production of crude rubber was in round numbers 146,000 tons. Of this amount 96,000 tons were Plantation Para; 37,000 tons Wild Para, and Caucho; and all other rubbers, no matter from what source, made up only 13,000 tons. About 100,000 tons, or 68½ per cent, were shipped from British possessions in the East Indies. South America supplied only about 38,000 tons, or 26 per cent. The other 5½ per cent, which amounts to 8000 tons, came from Africa, Mexico, and several Dutch colonies. Late in 1914 Great Britain declared an embargo on all shipments of rubber from any point in the Empire, which was to take effect early in 1915. Obviously to have 68½ per cent of the world's supply cut off, would cause considerable hardship. Diplomatic negotiations were futile, and only by the acceptance of every condition demanded by England was the Rubber Club of America able to have the embargo lifted. We were given a taste of conditions such as Holland has had to endure in all her imports.

American plantations would act as a stabilizer. Any unreasonable demands would be balanced by an increase in home production. It is said on very good authority that washed and dried plantation smoked sheets can be laid down in New York at a profit at 25c. per pound. Evidently the planters are reaping something

of a harvest. Taking an average price of 88c. per pound, the profit must be something like 63c. or 250 per cent over and above the net cost. Since America uses around 60 per cent of the world's production, it is evident that we are paying too high a price for rubber. From the standpoint of economics this money should stay in the country.

Of all rubber-producing plants, only Guayule grows wild within our borders. In the Big Ben territory in Texas a large district, only second in size to the Chihuahuan field in Mexico, is available. Why not extend this field over the arid lands of New Mexico, Arizona, and Nevada? Waste land would be utilized, and a valuable product secured.

Guayule is not new to the American rubber man, unfortunately it is almost ancient history to him. It is safe to say that there are scattered over this country at least fifty abandoned deresinating plants, intended primarily for the treatment of this rubber. At one time they furnished about one-fifth of the entire rubber used in this country. The total production of the Mexican Guayule fields was about 10,000 tons of the washed and dried, but not deresinated, rubber per year, from 1905 to 1910. In 1911 it began to fall off, and the recorded production for 1912 is 3500 tons. About 80 per cent of this production was exported to the United States. Since 1912 Guayule has been comparatively unimportant.

This decline was brought about by internal conditions in Mexico, and by wasteful methods of harvesting. Since 1911 revolution after revolution has swept over that country, and conditions have gone from bad to worse until every legitimate industry is at a standstill. All peaceful industries are the prey of roving bands, who hold which ever allegiance seems most advantageous to themselves; bands of thieves, lead by men without principle, without patriotism, without honor; bandits who must be destroyed before peace can come.

Guayule was first discovered by J. M. Bigelow, M.D., in 1852, near Escondido Creek, Texas. While attached to the Mexican Boundary Survey he noticed the shrub, which the natives were in the habit of burning. On account of the high resin content, it burns like fat pine, and was highly valued for fuel. Through him, Prof. Asa Gray of Harvard obtained a sample, and he was the first to give it a botanical description. A part of this description follows:

"Parthenium argentatum, a well marked species connecting the sections *Agyrochaeta* and *Partheni-chaeta*; the leaves and branches whitened by a very fine and close silk-silvery pubescence, which appears to be wholly or nearly persistent. Leaves 1 to 2 in. long, including the tapering base and petiole; 2 to 5 lines wide, mostly acute, scarcely veined, beset on each margin with from 1 to 3 salient teeth, or sharp lobes. Flowering branchlets, slender, 4 to 8 in. long, nearly leafless and peduncle like, bearing 3 to 7 subsessile heads in a cluster."

The name Guayule is properly applied only to *Parthenium argentatum*, Gray. There are certain other plants of related species that closely resemble it, which led to

considerable over-estimation in the early surveys. The botanical name refers to the silvery luster of the leaves, due to closely set air containing hairs on the surface.

The plant is peculiar to the Chihuahuan desert, and is found principally in the northern portion of the Central Plateau. The area is close to 130,000 square miles, not all of which carries guayule. Endlich (1905) estimated the actual shrub-bearing region as about 34,000 square miles. Lloyd, "Guayule," 1911, bounds the region as follows:

"From the western extremity of Presidio County, Tex., the western boundary runs somewhat west of south, till it reaches the northern boundary of Durango, near Santa Barbara, Chihuahua. From this point the line turns approximately toward the southeast, running parallel with the Mexican Central Railway at a distance of about 100 kilometers. Beyond the State of Durango, the boundary turns still further to the east, curving northward again not far from the City of San Luis Potosi. The 101st meridian marks roughly the eastern boundary, lying somewhat west of it till beyond Saltillo, where the boundary then curves slightly west of north, reaching the eastern limit in Texas at about Langtry. The northern limit is marked approximately by Ft. Stockton."

This area has an altitude of from 2000 to 10,000 ft. above sea level, but most of the acreage will be found around 6000 ft. Unlike Hevea, guayule can withstand comparatively low temperatures. Records have shown it to stand a temperature of 5 deg. Fahr. at Marathon, Tex., and of 10 deg. Fahr. at Tucson, Ariz. Very little rainfall is necessary since the plant seems to thrive in districts where the annual rainfall is around 10 in., but the growth of the plant is proportionate to the precipitation. Irrigation has been recommended, and wherever tried has given excellent results. The plant grows during the rainy season, and the transformation to rubber takes place during the dry time. A rocky, calcareous soil is most favorable. From these data it is evident that the guayule shrub is quite hardy, and its cultivation should not be nearly as difficult as that of Hevea Brasiliensis.

It is quite true that the problem presents radically different angles. For one thing, *Parthenium argentatum* is a weed, and seems to be as perverse as most weeds. Up to 1911 Lloyd writes that the facts had not warranted cultural trials on a scale sufficient to make available a crop of anything but limited experimental size. Since then about all the guayule on the market has come from Texas, and experimental planting seems



FIG. 1—GUAYULE SHRUB

to have discontinued. The nonsuccess may be due to over-cultivation rather than the lack of it.

By the application of the principles of forestry, the supply of the shrub can be greatly conserved. For a long time it was customary to pull the plants up by the roots, instead of cutting them off level with the ground so that new shoots might be sent up in the next growing season. It was also general practice to pull up all plants regardless of size. This was a serious mistake, and later the harvesters restricted themselves to plants of at least 16 in. in height. Five years later another crop of 16-in. plants would be available. Fifteen years is regarded as the rotation period, and the maximum economic efficiency is reached when the plant attains a height of from 12 to 16 in. Fig. 1 is a fair example of a full-sized shrub. In 1905 Endlich estimated that the total supply was not much greater than 37,500 tons of shrub. This estimate proved quite conservative, but in 1911 various observers agreed that about four-fifths of the original supply had been gathered.

Parthenium argentatum is remarkable among all rubber producing plants in that caoutchouc occurs as such



FIG. 3—DISCHARGE ARRANGEMENT FROM MILLS

2. *By chemical methods:* Caustic soda has been used to attack the cell walls. The principle is quite similar to that of alkali process reclaiming. In this case the wood fibers, *i.e.*, cellulose, are hydrolized, and the rubber set free. In addition to removing the wood, a portion of the contained resin is also rendered soluble. This resin content varies from 23 to 28 per cent, and is, according to Hinrichsen, 78.2 per cent unsaponifiable. In this manner the resin content is cut down to about 18 to 23 per cent. These figures are based on the washed and dried rubber. The chief difficulty with this process is in washing out the last traces of alkali, which will act as an unregulated accelerator, and the rubber is quite liable to harden up on aging.

3. *By mechanical means:* By far the largest proportion has been produced by this process. The plants are first thoroughly washed so as to remove any dirt or dust, which in subsequent stages would be attached to the rubber. They are then given a medium coarse grinding between corrugated rolls. The resulting mass is transferred to a ball or pebble mill, where it is ground to a pulp. The customary charge is as follows: One-third of its volume of pebbles, one-half of water and about 6 to 8 bushels of shrub. The mill is rotated at about 30 r.p.m., and the grinding time is from ninety minutes to two hours, depending on the quality of the plants. The dirty water is drained off and the pulp run into tanks, where the rubber, carrying considerable wood, floats, and is skimmed off. This is the first separation.

It is further purified by completely waterlogging the ground wood by subjecting it under water to a pressure of over 200 lb. for sometimes as long as two hours, after which it is run into a beater, which greatly re-

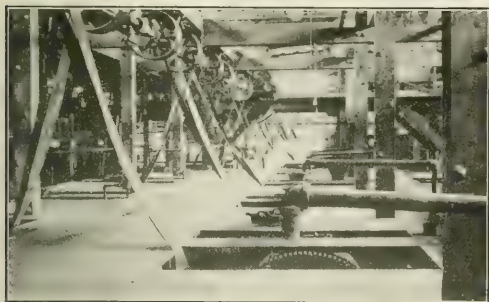


FIG. 2—CHARGING FLOOR OF GUAYULE FACTORY

in the plant structure. In *Hevea Brasiliensis*, it is present in colloidal suspension in the latex. The rubber content of the different parts of the shrub, as given by Whittelsey, is as follows:

Trunk bark	21.4 per cent
Root bark	19.5 per cent
Branches and leaves.....	9.7 per cent
Trunk wood	0.0 per cent
Root wood	2.0 per cent

Based on perfectly dry material, the percentage of rubber in the whole trunk is 9.9, the whole root 7.8, the leaves and branches 9.7, and in the whole plant 9.5. If mill weight is taken as a basis, the percentage of rubber on the whole plant is 7.8, which figure is very close to that gained in factory experience.

Since the rubber is contained in a cell structure, and will not escape by bleeding, certain methods of extraction are necessary. Three methods have been used with more or less success; they are as follows:

1. *By means of solvents:* The shrub is given a preliminary washing and grinding, and is then treated with a mixture of acetone and gasoline, which dissolves out the rubber and the resin. On filtering this solution any sticks or pieces of stone are removed. By increasing the acetone content in the solution, the rubber is precipitated out in practically the deresinated state. This process never had a very wide application, principally because the factory would have to be located in Mexico or Texas, and cold water, which is of prime importance to every deresinating plant, is not there available in sufficient quantity.

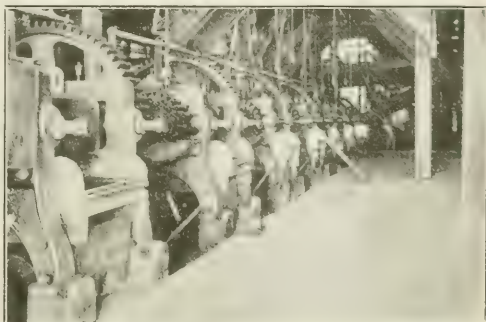


FIG. 4—GROUP OF WASHING AND SHEETING MILLS

sembles those in use in the paper mills. This pulp is run into settling tanks, where the wood and some of the rubber, called sinkers, or bagasse, settles. The remainder, which floats, is separated by skimming. Sinkers amount to about one-twelfth or 8.33 per cent of the rubber content.

U. S. Patent 979,902, Jan. 8, 1910, to H. T. G. Van der Linde, is for a method of recovery of this loss. The wood fiber, sinkers, etc., are dried either by compression or heat to the consistency of wet sawdust, after which they are treated in a pebble mill with $\frac{3}{4}$ gal. gasoline per 100 lb. In a short time the rubber swells, and when again thrown in the settling tanks it rises and is skimmed off.

Instead of waterlogging under pressure, as above mentioned, it is sometimes customary to let the pulp soak for a couple of weeks in water. This treatment is said to give better aging properties.

Fig. 2 is a photograph of the charging floor of a guayule factory, from which the pebble mills are filled. Fig. 3 shows the discharge arrangements from these mills, and Fig. 4 a group of washing and sheeting mills.

The skimmed rubber is given a thorough washing on regular rubber washing rolls, from which it is sheeted preparatory to vacuum drying. Formerly guayule was shipped out with as high as 25 per cent moisture present. It is now all well dried, and bacterial action is thereby greatly retarded.

Commercial guayule contains about 75 per cent of rubber hydrocarbons, and does not differ from Highland Fine Para by any greater extent than do other second-class rubbers. On distillation with steam it yields from $\frac{1}{2}$ to 4 per cent of a volatile oil, which is laevo-rotatory and possesses a peculiar and quite distinctive pepper-like aroma. This oil was shown (P. Alexander, Ber, 1911, 4, 2320-2323) to consist mainly of laevo-pinene and sesquiterpene. If not removed it is liable to cause serious trouble on vulcanization of the rubber.

The high resin content is also detrimental, since the resins not only combine with sulphur, but exert a solvent action upon the rubber at the temperature of vulcanization.

But when they have been reduced by extraction to 2 or 3 per cent no difficulty is encountered and the rubber is comparable to Brown Crepe. It does, however, require slightly more sulphur than plantation rubbers, and it is customary in compounding to figure about 7 per cent sulphur on the rubber content.

The purpose of this paper has been to remind the American public and the American rubber chemists of the latent possibilities of this shrub. Surely American ingenuity is sufficient to conquer the perplexing problems of cultivation and propagation, and to build up within our borders, on land fit for little else, a truly American industry that will be a source of wealth in time of peace and a protection in time of war.

An Analysis of Tank Resistance in Electrolytic Refining

By Lawrence Addicks

The cost of power is always a considerable and usually a major item in any metallurgical process based upon electrolysis. In the ideal refining cell the energy consumption would be zero and the quantity of metal recovered per kw.-hr. therefore infinite, as the energy liberated at the anode would just offset that required at the cathode. In practice there are a host of resistances and counter electro-motive forces to be overcome, and a detailed study is necessary in order to understand the possibilities of improvement in any given case. In this article practice in copper refining by the multiple process will be inquired into as an example.

The pounds of copper recovered per kw.-hr. expended at the switchboard depends upon the current efficiency, the current density and the items, both real and apparent, which make up tank resistance. The last is the subject of our present inquiry.

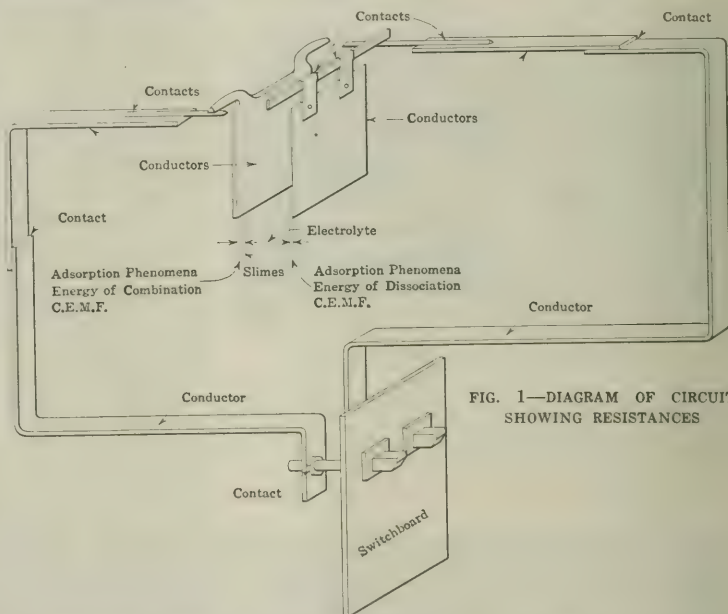


FIG. 1—DIAGRAM OF CIRCUIT SHOWING RESISTANCES

If we follow the course of the current from the positive pole at the switchboard, through the tank house and back to the negative pole, we shall find the series of obstacles to its passage shown in Table I, taking but a

TABLE I—CLASSIFICATION OF TANK RESISTANCE.

Item	Class	Nature
Busbar joints	Contact	Ohmic
Busbars	Conductor	Ohmic
Anode-contact	Contact	Ohmic
Anode lug	Conductor	Ohmic
Anode	Conductor	Ohmic
Surface-phenomena	Transfer	Ohmic
Solution of anode	Electrochemical	E. M. F.
Slimes	Resistor	Ohmic
Electrolyte	Conductor	Ohmic
Deposition of cathode	Electrochemical	E. M. F.
Surface-phenomena	Transfer	Ohmic
Cathode	Conductor	Ohmic
Cathode-lugs	Conductor	Ohmic
Loop-contacts	Contact	Ohmic
Rod	Conductor	Ohmic
Rod contact	Contact	Ohmic
Busbars	Conductor	Ohmic
Busbar joints	Contact	Ohmic

single tank in circuit for an example. This is also shown diagrammatically in Fig. 1.

It is evident that in actual practice we have the items in the tank proper multiplied by the number of tanks in a circuit, or, which is the same thing, we may work out the resistance per tank, apportioning to each tank its share of the busbar resistance.

The fact that for a circuit of a single tank the busbar resistance would be inordinate, has led to putting a number of tanks in series and then to a study of the relative arrangement of groups of tanks. The placing of additional tanks in series merely distributes the voltage drop in the leads between the switchboard and the tank house.

It has been generally considered good practice to keep the line voltage down to 200 volts or less, which places an upper limit of about 600 tanks in series. Actually circuits seldom carry above 400 tanks, and this is sufficient to make the incoming leads amount to but 3 or 4 per cent of the total voltage drop.

Fig. 2 shows the evolution of tank connections. *A* is the arrangement used in the first small installations. *B* is a modification employed at the old Anaconda refinery, long since dismantled. Here the parallel conductors resulted in halving the contact resistance between conductor-bars and tanks without using any more copper, as each bar was made half-size (*C*).

Then *A* was expanded into twin tanks, as shown in *D*. This resulted in halving the conductor-bars required, saving copper investment as well as voltage drop. Further, as the connections between twin tanks placed individual anodes and cathodes in independent pairs, it was claimed that a short circuit between electrodes in one tank was limited in its damage to efficiency by the resistance in series in the adjoining tank.

The old Anaconda tank *C* partly met this argument in that it was very wide, and two anodes were hung side by side from a single cross-bar. This required hanging the anodes by hooks, however, and this in turn increased the number of contacts.

Then came the Walker system, shown at *E*, where the idea of *B* was expanded indefinitely, it being found feasible to sacrifice accessibility, which was still preserved on one side of each tank at *D*, to power and investment saving. This resulted in a great saving in conductor-bars, and has been generally adopted. The connecting strips shown at *B* were dropped and a small triangular bar running the length of the tank partition

substituted without appreciable loss in efficiency. These bars are very small in cross-section, as they carry but half the current flowing through a single electrode when a tank is in normal condition.

Finally we have at *F* a further extension of the group idea, which has been proposed by several, in which the individual tanks are merged into one great basin, the Walker formation of electrode connections being virtually maintained, the tank partitions and triangular bars being replaced by a suitable iron beam to carry the load of the electrodes. This plan has received but a limited application, as it introduces in a modified form some of the disadvantages of the series system due to higher voltages without compensating gains. It would greatly decrease the first cost of a tank house, however, as well as that of tank repairs.

An idea of the magnitude of the different items constituting tank resistance may be obtained from Table II, which gives the results of an analysis I made a good many years ago of a tank house built on system *D*. It must be understood that the ohmic value given for counter electromotive force is simply the apparent equivalent

TABLE II—ANALYSIS OF TANK RESISTANCE

Item	Ohms per Tank	Per Cent of Total
A. Electrolyte	0.0000444	55.1
B. Metallic conductors	0.0000131	16.2
C. Contacts	0.0000113	13.9
D. Counter electromotive force	0.0000340	5.0
E. Slimes, etc., by difference	0.0000078	9.7
Total	0.0000806	100.0
A. Electrolyte	0.0000444	55.1
B. a. Leads	0.0000024	3.0
b. Conductor bars	0.0000085	10.5
c. Anodes	0.0000002	0.25
d. Cathode rods	0.0000010	1.2
e. Cathodes	0.0000008	1.0
f. Connection strips	0.0000002	0.25
C. a. Anode contact	0.0000026	3.2
b. Cathode loop contact	0.0000043	5.3
c. Cathode rod contact	0.0000044	5.5
D. Counter electromotive force	0.0000010	1.3
E. Slimes, etc., by difference	0.0000078	9.7
Total	0.0000806	100.0

under the conditions of operation, and further that in order to reconcile this resistance exactly with volts divided by amperes the current efficiency corrected for chemical corrosion would have to be allowed for.

Following this introduction, and keeping in mind that

it is possible to reduce any of these resistances to very low values by changes in either construction or methods of operation, we shall now discuss these possibilities item by item. We have in general (1) carrying the current to and from the electrodes, (2) from the electrodes to the electrolyte, and (3) across the electrolyte, and we shall re-group the items in Table I in this fashion in order to avoid repetition.

Conductors

These consist of the leads from the switchboard to the tanks, the connections between the leads and the electrodes themselves. As the resistance of a conductor varies directly as its length and in-

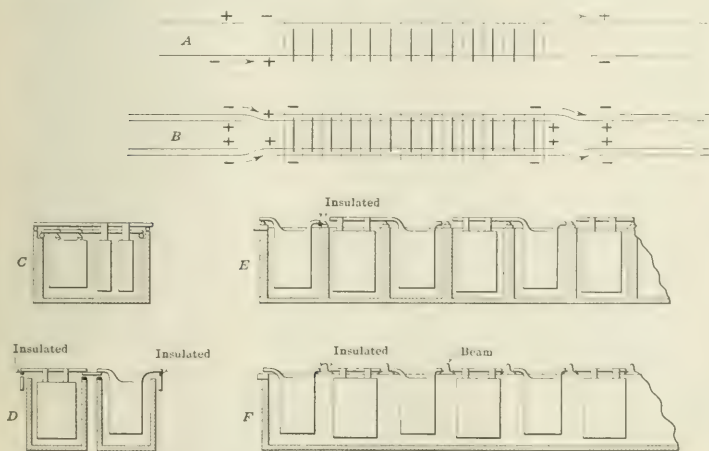


FIG. 2—VARIOUS TANK AND ELECTRODE ARRANGEMENTS

versely as its cross-section, while its first cost varies as the product of the two, we have from both points of view to make each connection as short as possible, while the cross-section involves a balance between first cost, the cost of power and sometimes strength. Carrying capacity does not enter as far as heating goes, as the other factors place this far on the safe side.

As we have a steady full load twenty-four hours a day, we can apply directly Thomson's law that the cheapest cross-section will be that for which the interest on the copper investment just equals the cost of the power lost by the voltage drop. The corresponding current density to be chosen for the conductors will vary greatly with the cost data for the individual case. This density is usually in the neighborhood of 500 amperes per sq. in., as against 1000 amperes commonly used in switchboard work.

Fig. 3 shows these relations graphically. A standard conductor 1000 ft. long and 1 sq. in. in cross-section, is taken, and two sets of curves superimposed, the first being the interest charges on the copper in dollars per year for different prices per pound for copper and various rates of interest, and the second being the power loss in dollars per year for different currents and various costs per kw.hr.

It is in this way possible to select the basic data and at once equate the two values.

For example, suppose we take copper at 15 cents a pound, interest at 10 per cent, and a kw.hr. at $\frac{1}{2}$ cent, we enter the diagram at the bottom on the 15-cent line, and note that it intersects the 10 per cent line at \$57 a year as our interest charge. This same \$57 a year line, however, intersects the curve for $\frac{1}{2}$ cent kw.hr. at an abscissa corresponding to 390 amperes, and as the conductor has 1 sq. in. area, this means a current density of 390 amp. per sq. in. An additional line on the diagram tells us that the voltage drop will be 3.4 volts per 1000 ft. of conductor. If we have 300 tanks on a circuit absorbing 0.32 volt each, and the generator is 500 ft. away, we should have a line voltage of 100 volts and 3.4 per cent loss in the leads, exclusive of any excess drop at joints in the bars.

The same principle applies to the various connections around the tanks, always remembering to figure out just what current each individual piece is carrying. Here, however, the element of strength enters in, and it may be necessary to make a cathode rod, for example, larger than is required for current carrying capacity, in order to obtain requisite stiffness. In some plants copper-covered iron is employed in such cases.

In the case of the electrodes themselves, the body of the cathode and anode are of ample cross-section. The cathode loops, however, are sometimes overlooked. Suppose we have a ca-

thode 3 ft. sq., operating at a current density (of electrolysis) of 20 amp. per sq. ft., hung by two loops, each 3 in. wide, cut from starting sheets 0.02 in. thick. We shall have a current of $3 \times 3 \times 2 \times 20$, or 360 amp. carried by a conductor $4 \times 3 \times 0.02$, or 0.24 sq. in. in section, giving a density of 1500 amp. per sq. in., or far above the economical range.

The anode metal will be of low conductivity, but the lug through which the current enters is usually of ample size.

Contacts

It has been shown that the size of the metallic conductors is specifically determined by the cost of power and other considerations. In the case of contact resistances we have no desirable value, the proper course being to make them just as small as possible. Experiments show a contact resistance to be truly ohmic in character, the voltage across a given contact increasing directly as the current is increased. It appears to be due primarily to adsorbed air on the surfaces in contact, and secondarily to oxide or other foreign matter. Pressure and moisture lower the resistance.

We have two classes of contacts, one where permanent joints can be mechanically made, and the other where

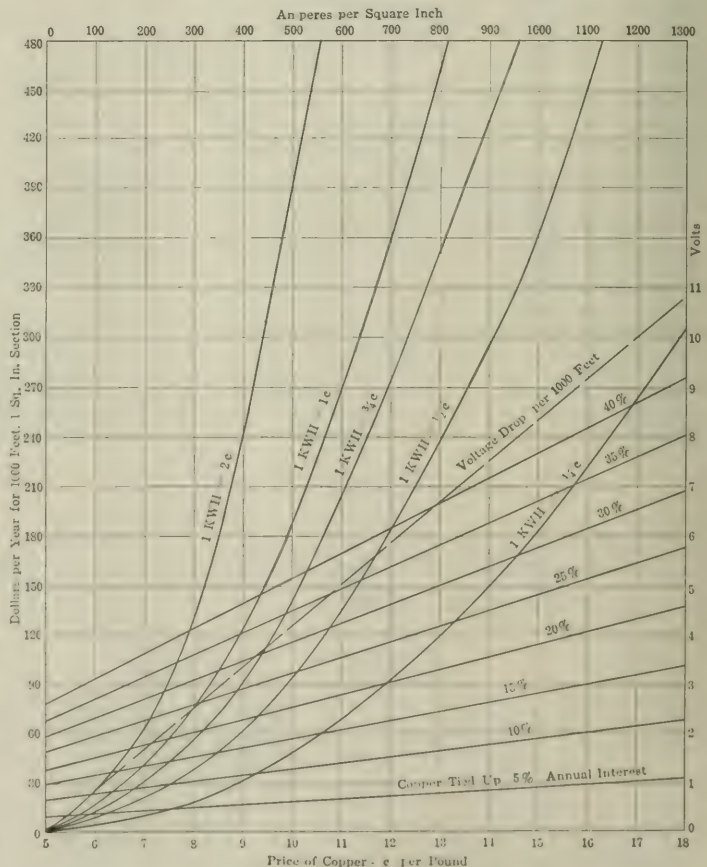


FIG. 3—DATA FOR DETERMINING MOST ECONOMICAL SECTION OF COPPER CONDUCTORS

Power cost is for year of 8760 hours. One cubic inch of copper taken as 0.0000007 ohms, zero temp. coeff. and 0.32 lb

temporary gravity joints must be used. It is customary on sliding joints, as in the case of switch surfaces, to keep the surface current density down to about 50 amp. per sq. in. In the case of busbars this figure can be greatly exceeded. A planed joint firmly bolted together will operate at 200 amp. per sq. in. without showing appreciable voltage drop—that is, 1 millivolt.

In the case of the loose gravity joints between the electrodes and their supports, we have one of the large sources of waste power in the system which can be attacked along three lines, namely, decreasing the number of contacts, increasing the acting pressure and improving the condition of the surfaces.

As the surest way of cutting down the resistance at a joint is to eliminate the joint, study has naturally been directed toward securing the minimum number of loose joints in series compatible with efficient handling of the electrodes. The various forms of anode and cathode suspension are shown in Fig. 4.

The anodes suspended by hooks have one single and two twin contacts equivalent to two series contacts; those

day as the anode dissolves away, and one of the loop contacts will show almost as high a resistance as the cathode bar contact, which has twice the current but twice the weight.

Various devices have, therefore, been tried to increase this pressure, notably plugs and clamps. At one plant holes were drilled in the anode lugs and these were reamed out to receive a tapered copper plug connected permanently by a short cable to the busbar. This is of no advantage if the original contact is kept clean, because we are dealing with such a low order of resistances that the short cable will have too high a resistance to be of much service as a parallel circuit. Of course, it does prevent excessive values for the joint, but with present-day methods of tank inspection these are not allowed to occur.

A number of years ago the writer tried out thoroughly the use of spring clips on the cathode loops and rod connections. These gave very encouraging results, cutting out over 80 per cent of the resistance. When the cost of renewing the clips from time to time, the labor of handling them and the additional hindrance in working around the tank was allowed for, some of this margin was eaten up. The great offset to such a plan, however, has been the improvement in keeping contacts clean, taken up below.

Much has been done in the lowering of contact resistance by shaping one of the members as a wedge which will bring a heavy unit pressure upon the other. This is the idea in the triangular bar, and it has been carried further in the proposition to have a wedge of a different angle from a corresponding groove which would result in crowding.

Finally we have the very important matter of the condition of the two surfaces. Contact resistances develop considerable heat, and this

means that any drippings of electrolyte in the neighborhood of a contact will soon be converted into anhydrous copper sulphate forming a coating which effectually prevents a perfect contact.

The first principle is, therefore, to keep the contacts clean, and when set up the rods and under surface of the anode lugs are always brightened with sandpaper or its equivalent.

Various means have been tried for making a better union physically. Mercury cups are not practical for many reasons, but amalgamating the surfaces is possible. This gives excellent results, but the cost of the amalgam used, plus that of the labor applying it, amounts to more than the saving.

At one time a scheme was advanced for keeping the anode and cathode rod contacts wet by substituting shallow copper gutters for the triangular bars and allowing water to flow therein. This also gave good results, but at too great an expense for proper maintenance. Finally it was found that oiling a contact after shining it did not interfere with the contact itself, while it did serve to keep it clean for a long time, and cost almost nothing to apply.

The result of these various developments has been to

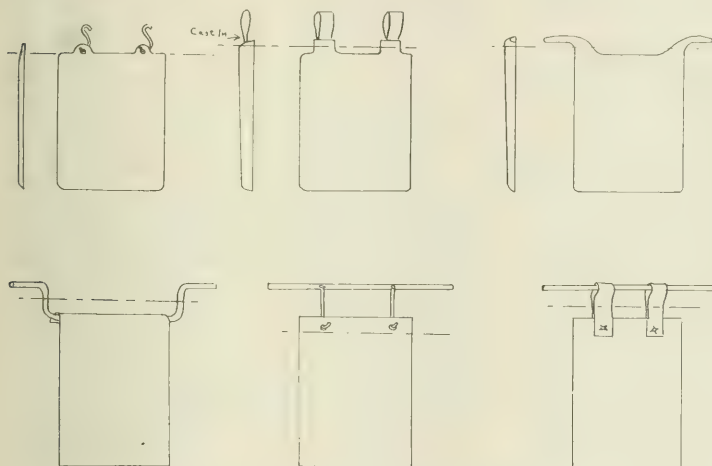


FIG. 4—VARIOUS FORMS OF ELECTRODES

with loops, one single and one twin, equivalent to one and a half; while the standard anode, with cast lugs, has but the single contact at the conductor or triangular bar.

The cathodes have gone through the evolution shown. The first example gives but a single contact, but has been abandoned on account of trouble with the rods in spite of painting at the solution line. The others give one and a half contacts, but a more reliable method of suspension. The part of the loop beneath the surface of the liquor does not matter, as this joint is soon covered by the deposited copper.

At one of the refineries work has been done on eliminating another contact by doing away with the triangular bars, allowing the cathode rod to rest directly on the lug of an anode in the adjoining tank. This is in effect returning to the connection shown at D in Fig. 2, but eliminating the connection strip.

The minimum number of loose contacts we can get along with is, therefore, one-half entering the anode, one-half at the cathode loops, and one-half leaving the cathode rod, or an equivalent of one and a half.

The pressure exerted upon the two surfaces has a great deal to do with the resistance shown to the passage of the current. For example, the contact resistance between the triangular bar and the anode increases day by

cut in half the values for contact resistance given in Table II.

It must not be thought that because the ohmic values are very small the financial equivalents are likewise so. Take the saving of one-half of 0.0000113 ohms per tank just spoken of, and assume power at $\frac{1}{2}$ cent per kw.hr., 10,000 amp. on a circuit and 1500 tanks in the tank

house. The saving will be $\frac{0.0000113}{2} \times \frac{10,000 \times 10,000}{1000} \times 1500$ or 848 kw., equivalent to $848 \times 24 \times 0.005$ or \$102 a day.

Transfer Resistance

We come now to the transfer of the current between the electrodes and the electrolyte. This is a field which is very difficult to properly resolve into the several component factors. In true refining the total value is not very great, but bad conditions, such as poor circulation of the electrolyte, foul anodes, etc., may greatly increase the normal value. In general, we have to deal with counter electro-motive force, the ohmic resistance of an absorbed gas film and the screening effect of the slimes.

The counter electro-motive force is the opposing voltage due to the cell acting as a battery, and is due to the difference in composition between the anode and the cathode, and to the differences in concentration of the electrolyte around the two electrodes.

The first cause is small in its effect except in the insoluble anode tanks used for controlling the copper contents of the electrolyte which operate at about six times the voltage required for refining cells.

The second is due to the fact that the circulation of the electrolyte, which must be gentle in order to avoid stirring up the anode slimes and thereby contaminating the cathodes, is not sufficient to sweep away from the face of the anode the descending layer of solution rich in copper sulphate formed by the electrolysis, nor the corresponding lean layer which rises at the surface of the cathode.

This forms a Cu—CuSO₄—Cu concentration cell with a small electromotive force tending to equalize the differences in concentration and therefore against the applied voltage.

It is quite easy to measure these two effects jointly by taking careful current-voltage readings while varying the current over a range not great enough to seriously change the conditions. If these readings are plotted and a straight line drawn through the points, this line will intersect the voltage base line at the value of the counter electromotive force on the circuit. In practice this amounts to from 0.01 to 0.02 volt per tank.

The ohmic resistance of what is doubtless an adsorbed gas film on each electrode is considerable and under some conditions may become enormous.

If we explore the potential gradient between anode and cathode we shall find a sudden drop as we leave the anode, a gradual slope across the electrolyte and another sudden drop as we reach the cathode. This film acts as a true ohmic resistance and has a temperature coefficient.

The various addition agents which have proved of such assistance in obtaining smooth deposits act markedly on this resistance. A moderate dose of gelatin in the electrolyte will increase the overall voltage required as much as 40 per cent.

Then we have the screening effect of a curtain of poorly conducting slimes on the face of the anode. A well-refined high-grade anode makes a loose granular slime which offers but little resistance to the passage of the current; less favorable conditions result in a thick

greasy slime that is pierced in places by the current making for high resistance and irregular solution of the anode. The latter condition often results in what are sometimes called "crazy tanks" where a voltmeter across the tank will give no constant reading but jumps violently back and forth between a normal tank voltage and one about three times as great.

The value of the resistance due to adsorbed gas and sum of the values found for all other items and the total slimes can only be obtained by difference between the over-all voltage. This is generally about 10 per cent of the total resistance in circuit. This probably lies chiefly in the gas film and further study may discover some way of reducing this factor.

Electrolyte

We come finally to the resistance of the electrolyte itself and this brings up three questions, the necessary distance between anode and cathode, the composition of the electrolyte and its temperature. As the electrolyte comprises over half the total resistance in circuit, it is necessary that it be considered in detail.

The question of permissible electrode spacing belongs under the heading of current efficiency which we are not here discussing. It also depends upon the advisable age of electrodes, or particularly upon how many crops of cathodes correspond to a single set of anodes as each crop will operate on a wider spacing than the previous one. When three or more crops are drawn it may pay to respace the tank.

Spacing also is related indirectly to current density as additional density greatly increases the difficulty of working at close spacing. The foulness of the anode also has a bearing as voluminous or flocculent slimes demand greater distance in the interest of a clean cathode.

The average thickness of liquid column has been gradually reduced from 2 in. to about an inch and a half, due largely to better control of the physical character of deposits in late years. During the same period current densities have increased and the area of electrodes has been enlarged so that the full value of the improvement in deposit has been apportioned in several directions.

The composition of the electrolyte is very important. It may be considered to be made up of sulphuric acid, cupric sulphate, impurities in the form of sulphates or more complex compounds such as arseniates, etc., and finally addition agents.

The conductivity depends chiefly upon the mobile hydrogen ions from the dissociation of the sulphuric acid and, as would be expected, increasing the free acid within certain limits markedly lowers the resistance of the electrolyte.

There are limitations imposed by two difficulties. As we have a solution of mixed sulphates we are bound by the habits of isohydric solutions, the amount of dissociated hydrogen depending upon the relative concentration of the other sulphates as well as upon that of the sulphuric acid.

The other limit is due to the fact that too great a hydrogen concentration affects unfavorably the electrode surface phenomena discussed under a previous heading. The net result of these two limitations is that very high percentages of free acid do not give improved over-all results and it is not customary to carry above 13 per cent.

These same arguments require carrying as small an amount of copper sulphate in solution as shall give a satisfactory deposit at the cathode. This is borne out in practice although the variation in conductivity is not very great with changes in the copper concentration. A complete set of measurements of the conductivity of different mixtures of copper sulphate and sulphuric acid is

reported by Richardson and Taylor in Vol. XX of the Transactions of the American Electrochemical Society.

With good operating conditions the copper in the electrolyte can be carried down below 2 per cent without impairing the cathode deposit; were it possible to increase the circulation, even lower values could be considered. It is unwise to proceed too far in this direction, however, and values between 2.5 and 3.0 per cent are considered good practice. Even under difficult operating conditions there is no particular advantage in carrying over 3 per cent copper. The early electrolytes were carried at 4 per cent copper and 8 per cent free acid; these have gradually been modified to 2.75 per cent copper and 12 per cent free acid.

The specific resistance of such an electrolyte at 120 deg. Fahr. will be about 0.7 ohm per cubic inch. The various impurities in the electrolyte will increase this anywhere from 5 to 15 per cent so that a working value will be about 0.8 ohm. A reasonably accurate measurement of this resistance may be obtained with an ordinary voltmeter and two copper electrodes if the column of electrolyte measured be long enough to render negligible the voltage effects at the electrodes. Whether this length has been obtained may be tested by increasing it and seeing if any lower readings per unit of length are obtained. Eighteen inches between electrodes will generally be found sufficient.

The minute quantities of organic addition agents have probably but slight effect upon the conductivity of the electrolyte, their effect upon the resistance being at the electrodes. On the other hand, inorganic agents such as ammonium sulphate, used to be added in large quantities and these had, of course, to be reckoned with, any increase in sulphates tending to drive back the dissociation of hydrogen ions.

The temperature of the electrolyte is a very important matter. In the first place the electrolyte itself has a positive temperature coefficient of about 0.5 per cent per degree Fahr. There is not only this enormous premium set upon running with the solution hot, but in addition the electrode conditions are greatly benefited. The disadvantages are the cost of heating, the increased humidity of the atmosphere in the tank house and the increased growth of copper in the electrolyte by chemical action.

It is customary to heat the liquors to about 135 deg. Fahr. in the circulation wells and this temperature drops 20 deg. or so in passing through the system, resulting in different resistances in different tanks.

Some of the older plants had long cascades of tanks, the electrolyte flowing through five or six tanks in series; modern plants have generally but two tanks in series so that the temperature inequalities are not so severe as formerly.

We have now discussed item by item the various components of tank resistance. In making these up into a sum to compare with the readings of the switchboard instruments we must see to it that we have properly allowed for the number of series-parallel circuits formed by the multitude of anode-cathode pairs, for the proportion of tanks which are "locked out" so many hours a day for replacement of electrodes and cleaning of slimes, for the special conditions in insoluble anode tanks and finally for the negative factor introduced by imperfect current efficiency which provides a by-pass or parallel circuit for a certain part of the current, the discussion of which will be taken up in a later article.

Franklin Institute.—A lecture will be delivered on Dec. 14, 1916, at the Franklin Institute, Philadelphia, Pa., by Prof. C. C. Thomas of Johns Hopkins University, on "The Cooling of Water for Power-Plant Purpose."

New Courses in Industrial Chemistry in England

The Bradford Technical College, Bradford, England, realizing that the war has given impetus to various chemical industries, has prepared, according to Commerce Reports, a comprehensive scheme to afford training to students preparing to enter the chemical industries, especially the dye and textile industries. A pamphlet issued by the Bradford education committee gives particulars as to the courses, and states that there is likely to be an increasing field in analytical work for women. Usually, for appointment to a position as an industrial chemist a degree in chemistry from some university, a day diploma of one of the higher technical colleges or the associateship of the Institute of Chemistry is required.

The subjects for the diploma in chemistry and dyeing are:

Inorganic chemistry, physical chemistry, organic chemistry, chemistry of dyestuffs, principles of analysis, technical analysis, chemical calculations, glass working, analysis of dyes and fibers, color matching, dyeing and finishing, structure of yarns and fabrics, mechanics as applied to chemical industries, mechanical drawing, mathematics, physics, practical physics, descriptive electrical engineering, practical chemistry, experimental dyeing, practical dyehouse work, etc.

A similar course has been arranged for those who intend to take up work in other chemical industries apart from the textile side, such as oil and soap works, metallurgical, gas engineering, etc.

The college possesses a practical dyehouse, with full-sized machinery, providing opportunities for large-scale dyeing, and combined with this is a finishing plant for completing the commercial treatment given to cloth. In addition to facilities for special experimental and research work, visits to chemical works, gas works, sewage works, tar works, soap works, and dyehouses are arranged, so that students have an opportunity to see processes which have been described in lectures carried out on a manufacturing scale. There are also special courses in pharmaceutical chemistry, a branch of work which is now offering a continually increasing scope for women.

Proper Current Densities

By B. B. Hood

Assistant to the Superintendent, U. S. Metals Refining Company
Chrome, N. J.

When it is necessary to install large amounts of copper to transmit electric power the question of interest on that copper should be taken into consideration when figuring the size of conductors. The cost of operating such transmission lines may be taken as the interest on the copper tied up plus a certain per cent for amortization plus the cost of the power lost. For direct-current work this will be a minimum when the cost of interest, etc., equals the cost of power lost, since interest varies directly as the copper involved, while the power lost varies inversely. Having a certain amount of power to transmit, in order to figure the size of conductors, the proper current density should be determined. Into this problem will enter the resistivity or conductivity of the copper to be used, the temperature at which it is to be operated, the cost of the copper installed, the rate of interest on the investment and amortization, and the cost of power to be transmitted.

From the chart Fig. 1 the proper current density in amperes per square inch may be determined, and from it the size of conductors readily figured. Taking the example given find the point where the 93 per cent line

CHART I—PROPER CURRENT DENSITY FOR COPPER TRANSMISSION LINES

Example.—Copper bus bar having a conductivity of 87% (Mathiessen's Standard) to be operated at an average temperature of 38° C. Cost of copper 30c. per lb. Interest 1 amortization of investment 14%. Cost of current = \$10.00 per kw.-year. Proper current density = 655 amp. per sq. in.

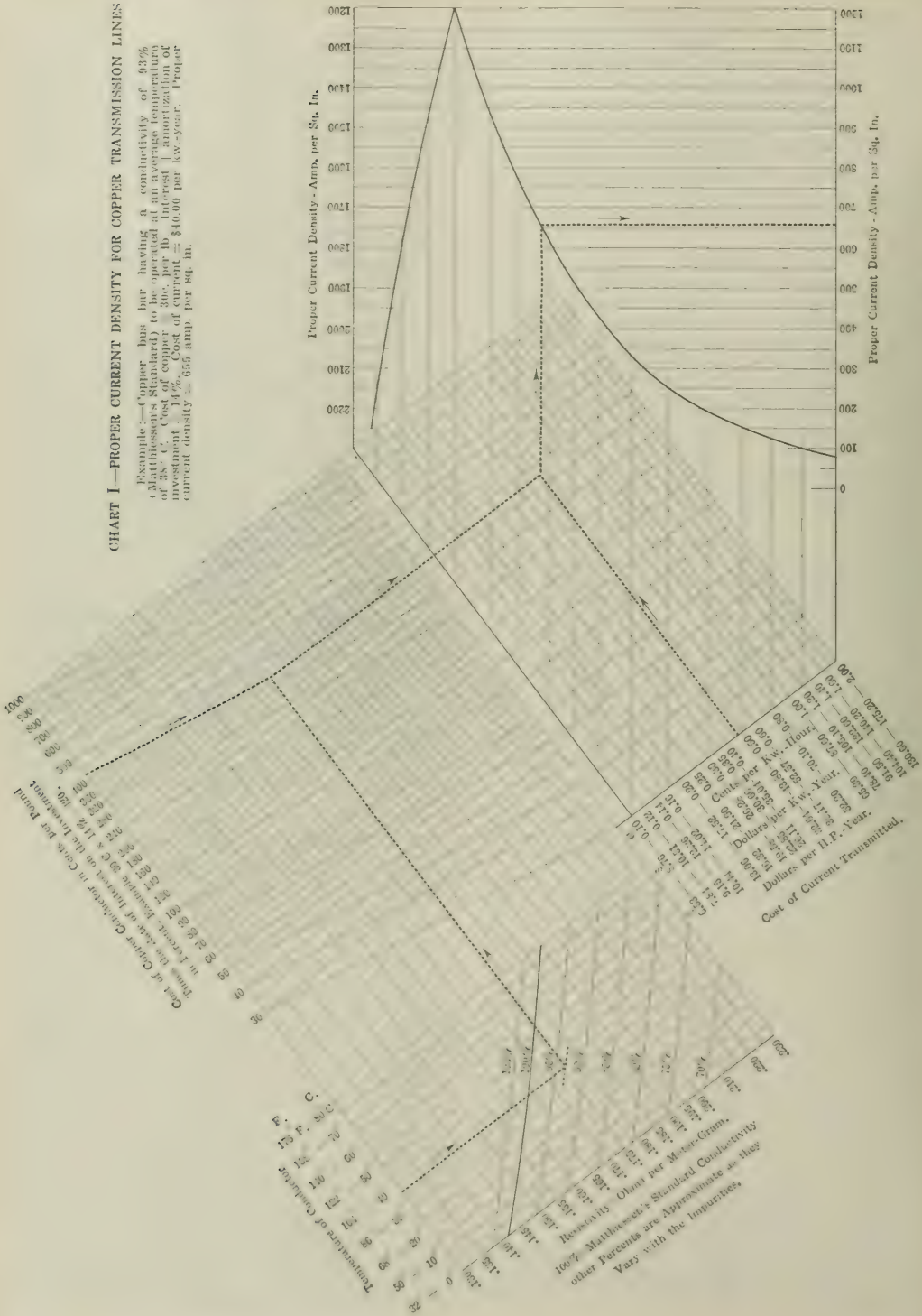
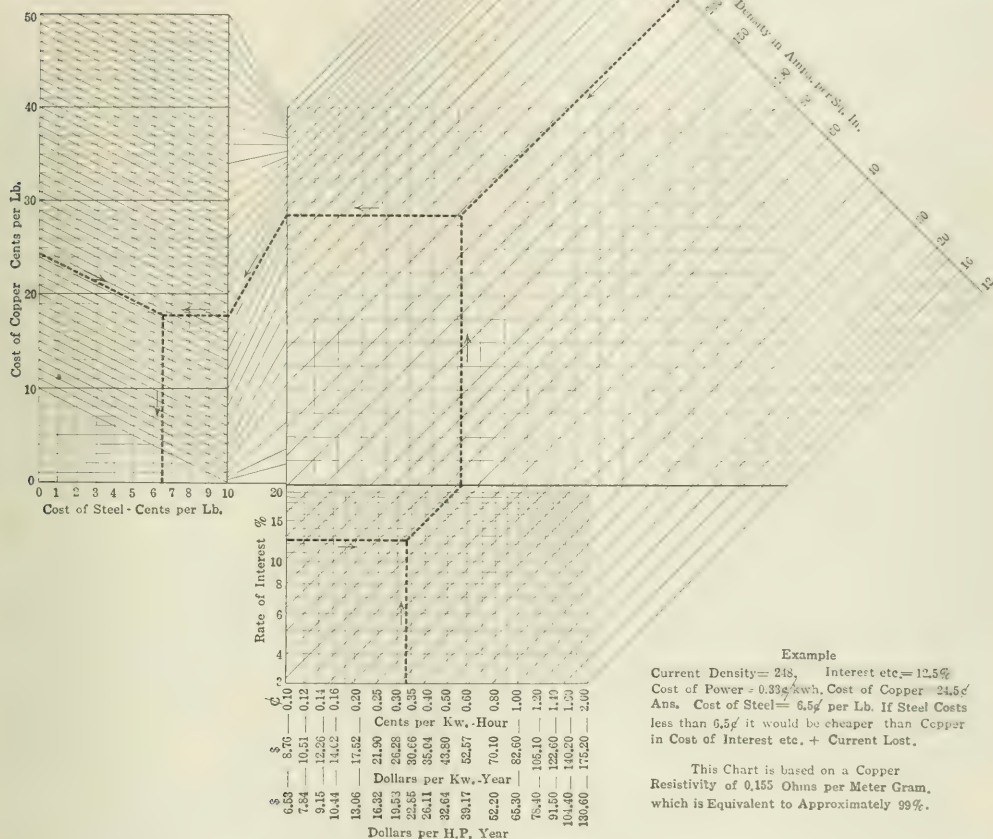


Chart II Copper vs Steel Conductors
of the same Cross Section Area

Showing the relations between, Cost of Copper, Cost of Steel, Rate of Interest and Amortization, Cost of Power Transmitted, and Current Density, when Copper Conductors = Steel Conductors in Cost of Operation.

Cost of Operation being equal to Interest on and Amortization of the Investment Plus the Value of the Power Lost. Knowing Four of the Five Factors the other one can be determined from the Chart.



crosses the 38° C. line. Multiply the interest of 14 per cent by the cost of copper, 30 cents, getting a factor of 420. From these points follow the dotted lines until the line representing the cost of power at \$40.00 per k.w. year is reached, from thence over to the curve and down to the proper current density 655 amperes per sq. inch.

Suppose we consider an electrolytic refining plant using copper conductors under the above conditions. If instead of using the proper current density, 150,000 lbs. of conductors were installed, using a density of 900 amperes, what would be the yearly loss?

The interest charge on the investment would be \$6,300 per year. If the density of 655 amp. were used, the power loss would amount to \$6,300 per year. With 900 amp. the power loss will be $\left(\frac{900}{655}\right) \times 6300 = \$11,890$, or

a total of \$18,190 per year for operating. This makes no allowance for the increased temperature of the conductors above 38 deg. C., which would take place and increase the loss. If the installation were made so that

655 amp. per square inch was obtained, there would be 900

$\times 150,000 = 206,200$ lb. of copper conductors installed

which would have an interest and power cost of \$8,660 per year each, or a total of \$17,320. This would make a saving of \$18,190 — \$17,320 = \$870 per year over and above all allowances for amortization, etc.

Some times a conductor must be large enough to support a weight such as a cathode. In that case it may be possible to substitute steel with a saving, providing, of course, there are no other conditions which do not prohibit the use of steel. From the chart in Fig. 2 it is possible to determine whether steel will compete with copper in cost of operating. If in the example given steel costs less than 6½¢. per lb. installed it would be cheaper to use than copper. This situation exists largely because a lower current density is used than would be proper if the conditions, upon which the chart in Fig. 1 is figured, were all that were considered, instead of bringing in the question of strength.

Chrome, N. J.

Some Recent Developments in Scientific Instruments and Materials*

By Edward Schramm

In considering the relation of the Bureau of Standards to things "made in America" we must make clear at the outset that its primary contribution lies not so much in the development of special products as in the acquisition of knowledge through tests and investigations, and the spread of information by means of publications and a large correspondence. To cover the broad field of the bureau's work lies quite without the scope of this review, and a few examples must suffice to indicate the nature of its activities.

Within the past few years the testing and certification of radium products has been undertaken; this work has enabled the purchaser to discover exactly what he was getting and has thus removed the element of uncertainty and danger of fraud from the industry.

The preparation and sending out of standard samples of materials of certified composition or properties by means of which laboratories may easily check their methods of analysis or testing is an important part of the bureau's work.

The bureau is co-operating with technical and scientific societies and manufacturers in the attack on certain important problems of industrial interest, among them the following: A comparative study of the effect on quality of rails of several methods of producing ingots; an investigation of the factors influencing the operation of electrotyping baths; investigations of methods of minimizing the destructive action of stray electric currents on underground structures; investigations of the fire resisting properties of structural materials, in co-operation with the Fire Underwriters and Mutual Laboratories and various engineering and industrial societies and associations; investigations relating to the elastic properties of steel columns in co-operation with the American Society of Civil Engineers and the American Railway Engineering Association.

Leaving these broader aspects of the work of the bureau, the remainder of this review will be devoted to a field in which it has a special and immediate interest, that of instruments and materials for scientific uses. In what follows, a necessarily brief account is given of some of the bureau's experiences with such products.

Measures of Mass, Length and Volume

Let us consider first the fundamental measurements of mass and length.

Balances and weights of the same grades as those obtained in Europe have been made in this country for many years. Many foreign balances have been imported in the past because of their lower prices, and some because of the reputation of the makers, but only a few special types could not be obtained in this country. The war has made no apparent changes except greatly increased production.

With regard to volumetric glassware the situation appears to be that American makers can make fine apparatus if they will, but that they find greater profit in the bulk production of common articles, a statement which applies to many other lines.

For tapes and other measures of length there is a tendency to replace ordinary steel by iron-nickel alloys. The dimensions of the alloy containing 36 per cent nickel along with small amounts of manganese, silicon,

and chromium, in all about 1 per cent, were found by Guillaume to remain almost invariable with ordinary atmospheric changes of temperatures. For this reason it was called "Invar," and has been manufactured under that name in France. The Bureau of Standards is conducting an investigation in co-operation with a steel company for the purpose of producing American steels of specified thermal expansivity, combined with stability of dimensions and other desirable properties.

At present steels of small expansivity are being studied to determine the effect of various thermal, magnetic, and mechanical treatments as well as of slight variations in the constituents. This has already resulted in the production of specimens which, as far as small expansivity is concerned, compare favorably with good French "Invar"; but as yet sufficient time has not elapsed to show how stable they can be made in regard to constancy of length.

An important material, the supply of which was cut off by the war, is the finer grade of sieve cloth used in the testing of cement and similar products. American manufacturers are making every effort to duplicate this cloth, but some of their product appears lacking in the desired uniformity.

An alternative method of cement analysis depending on blowing out the fine particles by a current of air has been investigated in the cement laboratory of the bureau. While requiring more elaborate apparatus and greater time than the sieve separation, it has the advantage of subdividing the material which would pass a 200-mesh sieve into four grades of fineness, thus giving a measure of the impalpable powder which constitutes the true active material of the cement. The method ought also to be useful in the testing of abrasives.

Electrical Instruments

America has always taken a leading place in the production of commercial electrical measuring devices, only a very small quantity being imported. Watt-hour meters, both the alternating-current and the direct-current types, were originally developed in this country, and are now being produced in enormous quantities by elaborate factory methods. Together with ampere-hour meters they are now being exported, even to Europe, in large quantities.

As in many other industries, one of the most characteristic features of American manufacture is quantity production. In many cases our manufacturers have made no effort to develop special forms of apparatus of the highest grade in which great refinement is necessary, and for which there is only a very small demand from universities and research institutions. Much of such apparatus has been imported from Europe, where small but successful businesses have been built on just such work. Of course, the highly skilled labor available abroad at relatively low wages has been an important consideration in this.

The alloy manganin which is of fundamental importance in most precision apparatus used in electrical measurements was developed in America, but has heretofore been imported from abroad. It is to be hoped that American makers will market this alloy as well as others of similar characteristics in sufficiently good and uniform quality to meet the requirements of the manufacturers of precision apparatus. There is also an unfilled need for certain highly specialized materials used in instrument manufacture, such as very fine wires and small circular levels.

In comparing American and foreign-made instruments, it may be noted that the preferences of the user, which may be very different in different countries, have had an important influence on design. Americans often

*A paper presented at the thirtieth General Meeting of the American Electrochemical Society, New York, Sept. 28, 1916, in the "Made in America" Symposium (see issue of October 1, 1916, page 365). Published by permission of the Director of the Bureau of Standards.

prefer to sacrifice somewhat in accuracy to obtain convenience and compactness. For example, certain foreign portable photometers are capable of greater accuracy than are American instruments, but the latter are much more compact and convenient to use, and their accuracy is sufficient to make them really more efficient in the work for which they are intended than are the foreign instruments.

It is interesting to note that two American manufacturers are producing galvanometers which are decidedly superior to any made abroad. The very highest grades of ammeters, voltmeters and wattmeters are available in American types. Very inexpensive direct-current instruments are now made in large quantities, particularly for automobile service. American manufacturers have not, however, produced alternating-current instruments in such inexpensive models as have the German and French makers. Hot wire instruments for radio work were formerly imported, but are now largely supplied by American makers.

Thermometers and Pyrometers

Nearly every type of thermometer used for laboratory or industrial purposes is now made by American manufacturers, such as clinical, calorimetric, Beckmann low-temperature, high-temperature (540 deg. C.), and various types of industrial thermometers. Practically the only exceptions are thermometers of special types, of very limited use, such as deep-sea thermometers, liquid pentane-in-glass thermometers for use down to very low temperature (—400 deg. Fahr.), and primary standard thermometers.

Industrial thermometers, sometimes called mechanical thermometers, are mercurial thermometers provided with special mountings to adapt them to special applications in the industries, *e.g.*, for galvanizing baths, annealing ovens, distillation apparatus, etc. In this field of thermometry, American manufacturers have taken the foremost position and are exporting their product even to the European countries.

It was formerly necessary to import thermometric glasses; an American firm has now placed on the market special thermometric glasses that are in every respect as satisfactory as the well-known Jena normal and borosilicate glasses. Quite recently this firm has developed and placed on the market a new glass having a very low coefficient of expansion, which adapts it to a wide variety of heating requirements.

In the development of pyrometers, a very marked progress has been made in late years. Until quite recently we were almost entirely dependent on the product of European instrument makers for all high-temperature instruments. To-day, practically all types of pyrometers, thermoelectric, electrical resistance, optical and radiation are being produced by American firms. New instruments, now in development, which will mark a noticeable advance will soon be placed on the market. Several new and very active firms have been experimenting in the past three years, and others have enlarged their scope and models.

We are still dependent, to some extent at least, on the products of European platinum refiners, for the platinum and the platinum-rhodium wires used in thermoelectric pyrometers. It is much to be hoped that some of our platinum refiners will place on the market thermocouples which, although purchased at widely different times, will yet be reproducible in their temperature scales to within 5 deg. to 10 deg. C.

Along with the developments in thermometry and pyrometry, there has been notable progress in the development of other instruments required in heat and temperature work, such as special resistance bridges

and resistance thermometers used in calorimetric work, recording instruments for use with thermoelectric and resistance thermometers, instruments for detecting and for recording the critical points of steels, electric furnaces and ovens, bomb and other special types of calorimeters, gas calorimeters of the flow type, etc. All of these instruments have successfully met the most exacting requirements of the laboratory and of the works.

In the recent developments, which have been briefly referred to above, the bureau has often worked in close co-operation with the manufacturer, and has thus often been able to render valuable assistance and also has been in a position to control, in a measure, the accuracy of these products.

Optical Glass and Optical Instruments

The chief factor in the manufacture of fine optical instruments is the production of suitable glass for lenses and prisms.

A well-known European maker through long years of experience and thorough investigation has developed glasses adapted to various special needs. It is hardly to be expected that such results can be duplicated in a day, any more than a dyestuff industry can be improvised, but it is gratifying to note that four or five American firms are attacking the problem of optical glass manufacture with marked success.

The Bureau of Standards is also taking up the question in its broader aspects and hopes to be able to contribute to our growing independence of the foreign supply.

There are few optical instruments not being made here to-day. We are making our own microscopes, spectroscopes, engineering instruments and binoculars, and are even exporting some of these articles. Perhaps the greatest need of this industry is the development of a body of highly skilled workmen.

Metals

America's rich endowment of minerals and her advanced position in the metallurgical art are matters of common knowledge. It would be impossible here to attempt to record the progress in this great industry, but it will not be out of place to mention several developments that may properly be considered within the scope of this review, for metals frequently form both the tool of the scientist and the subject matter of his investigations.

Platinum is one of the most indispensable laboratory materials, and American producers are making every effort to increase the supply. Notable quantities are being obtained from the copper refineries.

For the purpose of determining and thus indirectly maintaining the quality of platinum ware, a method of testing devised at the Bureau of Standards has proved of great value. The method consists briefly in determining the thermoelectric force of the article to be tested against known pure platinum and then reading from a curve the corresponding rhodium or iridium content. In this way it is possible to determine with accuracy the total amount of impurity and to predict the loss in weight on heating without in any way injuring the article.

As material for investigations the Bureau of Standards is at the present time greatly interested in the pure metals. Through the development and extension of electrolytic refining methods, American companies are now producing in considerable bulk the purest copper, aluminium, zinc, tin, lead, nickel, and cobalt. By melting point and other physical tests these metals have proved equal in quality for scientific work to the small samples formerly imported.

In the case of the commonest metal, iron, it was

found impossible to procure on the market a product of sufficient purity to form the basis of a projected study of this metal and its important alloys. The preparation was accordingly undertaken at the bureau. A metal containing only three or four-hundredths per cent of impurities has been obtained in a form suitable for the determination of various physical constants.

Chemical Glassware

Since it appeared that this country would soon be thrown entirely on its own resources for chemical glassware, a series of comparative tests of two foreign and three domestic makes has been carried out at the bureau.

As the details of these tests, now in progress, are to be published later, it will suffice here to present the results in the form of curves (Fig. 1) and to call attention to the excellent manner in which the American wares (2, 3, and 5) compare with the foreign products (1 and 4) as regards resistance to attack by various reagents.

On treatment with water, with potassium carbonate, and with sodium carbonate, foreign glass No. 1 proved markedly inferior to the other four.

On boiling with caustic alkalis the differences in behavior of the five makes are not significant, while on evaporating with such solutions all the glasses suffer such great losses that this treatment must be considered inadmissible.

With ammonia, ammonium sulphide and ammonium

chloride, and a mixture of strong acids, all the makes behaved excellently, No. 1 showing a somewhat greater loss than the others with ammoniacal solutions. It may be concluded in general from the data obtained that the problem of making chemical glassware in America has been satisfactorily solved.

Ceramic Products

KAOLIN PURIFICATION

In work done at the Bureau of Standards and elsewhere it has been shown that clays respond to colloidal reactions, and that caustic soda affords the best means of deflocculating most clays, that is, bringing about a greater dispersion by breaking up the larger particles into finer ones. In this manner the coarser, granular impurities of clay can be readily separated from the fine-grained clay substance proper, since the latter is kept in suspension.

The principles underlying the refining of kaolins and other clays, as well as the effect of alkalis in the so-called casting process have been brought out in two contributions of the bureau.

The process outlined has been installed in a plant in eastern Pennsylvania under the direction of the Ceramic Section and with excellent results.

PORCELAINS

A comprehensive study has been made of the various types of porcelain, both from the theoretical and the practical standpoint. It has been found possible to

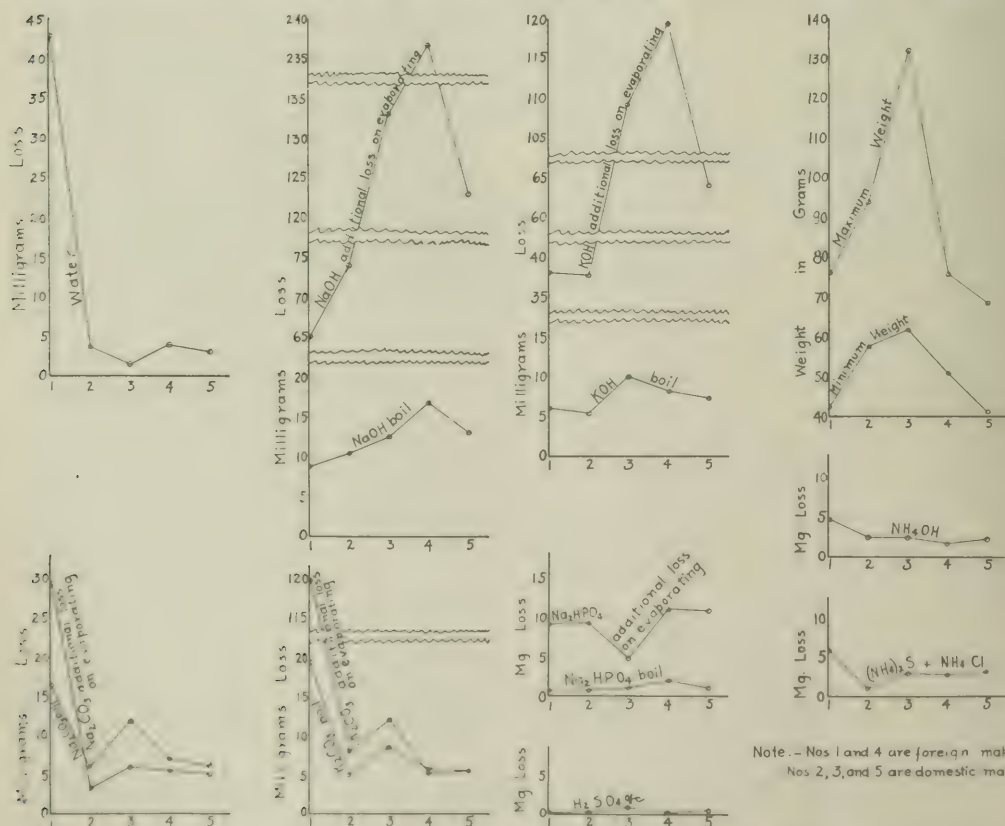


FIG. 1—LOSS IN WEIGHT OF BEAKERS ON TREATING WITH VARIOUS REAGENTS

Note.—Nos 1 and 4 are foreign makes
Nos 2, 3, and 5 are domestic makes

show clearly by means of petrographic examination what takes place in the vitrification of a porcelain and to differentiate between the several types of domestic and foreign porcelain. The temperature requirements in burning have likewise been established.

Simultaneously a number of hard porcelain compositions have been worked out which have been freely imparted to manufacturers interested in this work.

Owing to the impossibility of securing the refractory Marquardt porcelain, used for pyrometer tubes, etc., work was done in this connection. A very satisfactory body and glaze have been developed, the compositions of which have been made public. At the same time the ceramic section has co-operated with one firm and assisted in the installation of a plant for the manufacture of this type of porcelain.

PLASTIC BOND CLAYS

The failure of the supply of the European plastic bond clays used in the manufacture of glass pots, graphite crucibles, etc., has made it desirable to establish clearly the physical properties of the imported materials in order to make possible a comparison with domestic clays which are available. For this reason, five clays—four German and one French—were examined and tested.

From the results obtained, tentative specifications governing this type of clays have been suggested. It has been found that there is no reason why domestic clays should not be used to replace the foreign materials, but the fact is emphasized that not single clays, but mixtures of two or three domestic materials, should be employed.

By proceeding in this manner, satisfactory industrial results should be obtained, superior in fact to those with the use of the imported clays, since the latter possess certain defects which can be overcome. At the present time at least six American deposits of excellent bond clays are available. Considerable co-operative work has been done by the bureau with manufacturers interested in the use of these materials.

GENERAL REFRACTORIES

Considerable work is being done by the clay products section in assisting in the working out of methods of testing and specifications for the different classes of refractories. It co-operates rather extensively with such associations as the American Gas Institute, the American Society for Testing Materials, and the Refractories Manufacturers' Association.

The results obtained in connection with the work on the ability of clay refractories to resist load conditions at furnace temperatures have been generally confirmed.

Some attention is paid also to the development of special refractories such as the spinels, zirconia, and other substances. An elaborate study of silica refractories is under way.

Use of the Metric System

It would not be fitting to close this survey without some reference to an important step of progress brought about by the war. The growth of our trade with Latin America is forcing many manufacturers to adopt the metric system for their export business, and they are learning to think of grams and millimeters without an attack of mental prostration. The situation is well covered in Senate Document No. 241, 64th Congress, 1st Session, a report on the "Metric System in Export Trade," by the Director of the Bureau of Standards. The modes of use of that system are grouped as follows:

(a) Complete use of metric system in designing, making and selling.

(b) Price listing in metric equivalents (to enable the foreign buyer to understand quantities and prices).

(c) Packing products in units of metric size.

(d) Labeling metric equivalents on the unit packages the contents of which may be put up in customary units.

(e) Stenciling shipping cases for export with the quantities in metric units to meet the customs requirements in metric countries.

(f) Filling metric orders with the regular sized packages or products, merely billing in metric terms to enable the buyer to check price.

It is now possible to get all sorts of rules and gages, taps, drills, and other tools in metric as well as ordinary units. Perhaps the greatest benefit of the adoption of the metric system in export trade will be the reflex effect on the domestic market. Many metric products have been found available for home use, and we may look forward hopefully to the day when we shall have advanced as far as China in the adoption of a scientific system of weights and measures.

In conclusion, the author wishes to call attention to the fact that this paper is essentially a compilation and to express his thanks to the many members of the bureau staff who have contributed the information on which it is based. He is especially indebted to Mr. P. H. Walker for the data on chemical glassware, and to Messrs. P. G. Agnew, C. W. Waidner, and A. V. Bleining, who have written the sections on electrical instruments, thermometers and pyrometers, and ceramics, respectively.

Silico-Manganese.—The electric furnace of the Noble Electric Steel Company at Heroult on the Pitt, Shasta County, Cal., which has been in continuous operation since April 15 making ferromanganese and at times pig iron, is now producing silico-manganese, containing 50 per cent manganese and 30 per cent silicon.

New Steel Works for Norway.—Norway is increasing its iron industry by two new iron works, which will make ship plate and other shipbuilding materials. The larger of the two, the A/S Norskevalserverker, will be located near Christiansand and is capitalized at 5 to 10 million dollars. The initial output of the plant will be 80,000 tons of finished product. The second plant, which as yet is unnamed, will be capitalized at \$2,140,000 and have an annual output of 20,000 tons.

Enlargement of the South African Steel Works.—The small steel works at Vereeniging, Transvaal, South Africa, will be enlarged in the near future. The capacity of the present plant is 500 tons of steel a month, while the enlarged plant will produce 1000 tons in the same length of time. The materials used for the erection of the furnace will be supplied locally with few exceptions. The open-hearth furnace will be of the latest type and will have a chrome-ore hearth. (Commerce Reports, Oct. 13, 1916.)

Meetings of the Detroit Chemists.—The following meetings of The Detroit Chemists which is the Detroit section of the American Chemical Society, have been announced by the secretary, James H. Bogart:

Nov. 16, Dr. L. H. Baekeland, "Synthetic Resins."

Jan. 18, Dr. W. D. Richardson of Swift & Co., Chicago. Subject not yet announced.

Feb. 15, Mr. F. W. Steere of the Steere Engineering Co., "Producer Gas and Its Uses."

March 15, Dr. Louis Deer of M. I. T., "Color Photography."

April 19, Dr. C. E. K. Mees, "Photographic Research," an example of the work of a specialized research laboratory—to be illustrated.

The Brass Foundry*

By E. A. Barnes

In the brass foundry, as it existed thirty years ago, whether it was a separate institution doing a jobbing business, or an adjunct to a factory or rolling mill, the facilities which the moulders had at their disposal were far short of those available to-day. Considering the disadvantages under which the earlier brass foundries were operated, the workers in them should be given great credit for the work they were able to turn out.

Thirty years ago the brass foundries had but two choices of fuel, coke and hard coal; whereas to-day gas, coke, coal, fuel oil and electricity are available, and each, as you well know, has its own particular sphere of usefulness. The Fort Wayne Electric Works, I think, was one of the first electrical companies to adopt fuel oil in its foundry. We at first had to use the oil with much care, and it was necessary to do considerable research work in connection with the use of the oil, for the improved furnaces, burners and appliances available to-day were not then in existence.

A present-day brass foundry would certainly not be considered up-to-date unless it had compressed air for use in blowing off patterns, operating moulding machines, jarring machines and squeezers of various types. Even the individual work bench of the modern brass foundry is equipped with air nozzle and rapping hammer, enabling the workman to get along without assistance from his neighbor, except in special cases.

Modern foundries, too, make use of power-operated moulding machines of many various designs, which, compared to the crude hand-operated machines of earlier days, look as if they might be the last word in foundry advance, and yet we feel that we are only just starting to introduce modern labor-saving machines into the foundry.

The value to the brass foundry of an efficiency engineer and chemist is now unquestioned. Especially where the output of the foundry is quite large, the savings to be effected by having a chemist and engineer on the premises to run down troubles, develop special alloys and make suggestions for handling peculiar propositions are greatly in excess of the salary outlay.

With all our modern foundry equipment and the special services of engineer and chemist, the resourcefulness of the foundry is often taxed to the limit in solving some of the problems encountered. One proposition that was lately put up to our brass foundry was that of producing commercially large quantities of duplex thermostatic metal. It was necessary to cast or otherwise fuse together a brass alloy and a plate of nickel steel, the alloy to be of such a nature that it would stand rolling down to three-thousandths of an inch thick and even less, and the finished duplex sheet to be exactly 50 per cent brass and 50 per cent nickel steel. In order to secure the required results, it was necessary to have control of the casting of the yellow brass, which meant in the first place the necessity of pure copper. Curiously enough, we found only one particular brand of zinc that would give consistently satisfactory results in the alloy. Many experiments were tried, but either the brass cracked into small pieces or became detached from the steel plates; but by persevering in the experiments we finally developed an alloy which has the proper characteristics to stand the rolling and annealing process and remain firmly joined to the nickel steel. Our final result is a perfect metal for the purpose it is designed to fill.

A foundry problem which has many times puzzled us,

and other foundries, too, no doubt, is when and where to commence making use of metal patterns for repeat work. Our experience has been that it is best to make a first-class wooden pattern and use it as long as possible. We find that our engineers and designers frequently wish to make certain structural changes in the part after the first castings have been put into use, and since a wooden pattern usually can be much more readily changed than could a metal one, we use the wooden pattern at the start. Any unprotected wooden pattern, however, soon wears and warps, due to the rough treatment the pattern naturally receives; we have, therefore, been on the lookout for some method of increasing the life of the wooden pattern. In this connection we have been experimenting with the "Schoop" metal coating process.* With the "Schoop" pistol, copper or lead coating, as desired, can be applied to fragile and even complicated wooden patterns. This metal coating is supposed to render the patterns waterproof and stiffen them up so that they will hold their shape and more successfully resist the wear and tear incident to the moulding process. At this time we have not done enough of this work to pronounce it an absolute success, but the wooden patterns which we have coated by this process, some with the lead and some with copper, have given surprisingly satisfactory results. We believe that it only requires a little more research work to prove this system highly satisfactory and the scheme to use where the cost of metal patterns is not merited, and yet, due to extensive use, the ordinary wooden patterns become expensive from the need of being frequently replaced by new ones.

Another difficult problem with which we have had to contend is the making of aluminium castings which would take a high polish. This problem developed in connection with the furnishing of parts for therapeutic instruments, such as vibrators, etc. We tried all the standard alloys, but the castings invariably were full of small black specks due to gas in the metal. We were absolutely unable to get a satisfactory casting until we added from 8 per cent to 10 per cent of tin. In making this aluminium-copper-tin alloy we found it necessary to make up a rich alloy, cast it into bars and add this alloy to the aluminium at the proper time. The use of these eutectic alloys we have found very effective in securing results otherwise difficult to obtain.

The problem of producing brass and aluminium parts which shall be more homogeneous, tough and perfect than could be produced by ordinary casting methods has led to the development of the pressed metal process. Briefly, the process is as follows: A blank of copper or aluminium bar of sufficient size to contain the amount of metal required in the finished part is heated to a fairly high temperature. This hot blank of metal is then forced into a steel mould of the exact design and dimensions of the desired metal part. Powerful hydraulic presses, giving pressures from 500 to 2000 tons per square inch, are used to force the metal into the mould. This enormous pressure raises the temperature of the metal in the blank and causes it to flow into every part of the mould.

The results which are obtained by this process of forming brass and aluminium parts are wonderful:

1. The most intricate shape of piece can be formed by this process. Even ordinary newspaper size of letters reproduce perfectly on the finished part.

2. The pressed metal parts are formed so accurately to size and their surfaces are so smooth that in many cases no machining is required on the part after it comes from the mould.

*A full description of the "Schoop" process was given in this journal, Vol. XI, page 89 (Feb., 1913) and Vol. XII, p. 607 (Sept., 1914).—Editor.

*A paper presented at the annual meeting of the American Institute of Metals, Sept., 1916, at Cleveland, Ohio.

3. Where machining is required, the parts are found to machine much more easily than parts cast by any known methods. The cutting tool might almost be said to become sharper when used in cutting the pressed metal. The pressed metal has no tendency to cause the edge of the cutting tool to crumble or break.

4. The pressed metal parts are absolutely free from air and gas holes and sand. Because of the freedom from such gas and air holes, parts such as gas nozzles can be made by this process.

5. The pressed metal parts are much stronger and tougher than parts cast from the metals in question. Pressed metal brass parts are as strong as bronze or English gun metal, and can, therefore, often be substituted.

As regards checking system and systems of running foundries and cleaning rooms, such systems and methods are being widely exploited in the technical papers. In this literature there is a wealth of information for the foundry superintendent or owner who wishes to keep abreast of such developments. The technical papers are also a reliable source of information on modern foundry appliances such as core ovens, moulding machines, electric and air hoists, electrical and mechanical sand riddles, acetylene and electric cutting appliances, torches, dust collectors, etc. These appliances, of course, cost money, but in the end they are unquestionably of value in labor-saving and in keeping good workmen satisfied and interested in their work.

Pyrometers for measuring the temperature of the molten metals are indispensable in securing uniformly perfect castings. Where the foreman or melter has to judge the temperature by his eyes, misjudged temperatures resulting in sluggish metal, with consequent porous or otherwise defective castings, are all too frequent, for the light in the foundry easily influences the decision of the melter as to when the metal has been heated to the correct temperature for pouring. The pyrometers eliminate such errors in judging temperatures and, we believe, therefore, their use cannot be too strongly recommended.

I feel, however, that it is in the melting end of the foundry itself that we must look for the greatest advances in the near future. I believe that all of the present methods of melting will soon be replaced by much more efficient processes, either electrical or burning a gas derived from a fuel oil base by some method of premixing in a retort rather than by pulverizing and dividing the fuel oil and mixing with air, which produces the nebulous form of gas now used. The advances that have been made in electrical furnaces, ovens and retorts lead me to expect that in the near future electricity will compete on favorable terms with the various fuels for foundry melting purposes. I believe there is no doubt that some of the great electrical men are investigating along these lines and the results of their research should be disclosed in the near future.

"Safety" in the foundry, we are glad to note, has become an accomplished fact in all of our modern foundries. A stock of goggles, aprons, leggings and special shoes for foundry work is usually kept in the works' storeroom. In some cases these supplies are checked out to the workmen, while in other foundries they are sold to the men at actual cost; in most cases the use of this special safety clothing is insisted upon by the foundry management, and there is no question that it is a practice that all foundries should follow.

The new Ceramic Engineering Building of the University of Illinois will be formally dedicated on November 21 and 22. An industrial conference will be held in conjunction with the dedication.

Principles of Industrial Organization

By H. N. Stronck

Industrial waste elimination is fundamentally based on analysis and synthesis. Chemists and metallurgists have a special training in these branches of science and for many years have applied the principles of analysis and synthesis to the technical branches of their industries. It has, however, been comparatively recently that these same principles have been applied to the organization and business branches of industries.

What is known as scientific management originated in steel plants, and the laws and principles of this new science were first discovered and applied in these industries. The classical papers of Frederick W. Taylor refer almost entirely to work in steel plants and allied industries.

The chemical industries were among the first in Germany to investigate and apply scientific methods to their organizations. In this country we now fully appreciate the control which the German chemical industries have of the production features of chemical manufacturing. The Germans, however, realized that in order to become more supreme, still further economic results could be obtained by eliminating all possible wastes of organization and management. German efficiency is now a by-word in our press. In analyzing this, we find that the German worker as an individual is not as great a producer as the individual in our American industries, but that the secret of their success lies in the highly efficient development of organization control.

To date, comparatively little has been done in applying the spotlight of analysis to our wastes of organization. We all realize that there is a great difference in the management methods of similar concerns, but very little has been accomplished in the development and application of a standardized and highly efficient method of organization and control in the large majority of our chemical and metallurgical concerns.

Analysis and Synthesis in Organization

Chemistry teaches us that by combining certain elements in the right proportion, a product of value results. Similarly, in management, a combination of well established principles, judiciously applied, will result in a high type of management. Therefore, in determining the status of an organization, we must compare it with principles which we know are right, and see where and to what extent these principles are neglected. We must diagnose present conditions. After the weak points have been found, these must be eliminated by the substitution of fundamentally correct methods, and the entire organization brought to a strong, concrete whole. This is synthesis.

In the past, the organization and development of large and successful businesses was done almost entirely by the forceful use of synthesis with very little conscious application of analysis; and as a result accidental organizations were developed which could not take care of sudden booms and slack periods, and in which the loss of one leader often produced disastrous results. Accidental organizations were the ones that broke down under the stress of changing conditions. However, in those days, there was a large margin of profit to draw upon. The wastes were great, but no greater than that of a competitor, and in order to be successful, the management of an enterprise need only be as good as that of its competitors. In the last fifteen years there has been a great development in the application of analysis to management problems.

The first step was in a desire to obtain the money value of different operations, and cost-accounting

methods came into vogue. The next step commenced when manufacturers began to realize that the day-work method of wage payment was not satisfactory and they commenced the introduction of wage payment systems based on effort. Here the time element comes into consideration. At first this time was determined by rule-of-thumb or guess-work methods, and finally the new and scientific method of time-study was evolved and is gradually superseding the old guess-work methods of determining how long it should take to perform an operation. This time-study method of analysis taught us many other things, such as, that our methods of handling materials and the routing of materials and tools, were in a wasteful state; that our buildings were not designed in a manner to encourage greatest efficiency; that our machines were not placed in such positions that the distance of travel of the material through the processes of manufacture was not at a minimum; that time losses occurred due to incomplete instructions issued to the operating department by the office; that too much planning was done in the shop and not enough in the office, etc. The more analysis was applied, the greater the field of its application developed, until today it is applied to all steps of operation from the purchase of the raw material to the delivery of the finished product to its destination. As a result, new and elastic organizations were built up, which grow naturally as the business grows.

For the purpose of visualizing the problem, this article will endeavor to show just what points must be considered in developing a high type of organization.

Fig. 1 shows the functions and sub-functions of organization.

Fig. 2 shows the functions of operation and the relationship between these and the other functions.

The Function of Planning

The most important function of any organization is that of planning. In order to obtain the highest results of operation, the planning function must be developed to a highly efficient basis. The success of any organization is dependent upon the thoroughness and practicability of its plans. The degree to which planning should be carried out depends considerably upon the type of industry and the personnel of which it is composed. The ideal is to have a strict division between planning and operation. This ideal is difficult of attainment in practice, however it should be constantly borne in mind and approached as closely as is practical.

In our chemical and metallurgical industries, planning is divided into two main divisions, technical and operative. Because of the highly technical features of these industries, the technical branch of planning must be well developed, for the function of operation is greatly dependent upon the efficiency of the technical plans. Our chemists and metallurgists are well trained in the technical features; and hence, in the successful industries of this type, the technical planning is on a sound basis. The general lay-out of operation is based on technical planning. It is in this function that the start is usually made in the upbuilding of an organization for these industries.

It is the function of technical planning which answers the question of WHAT is to be done. This consists of the development of the standard formulas of what is to be produced, and in part of planning methods which will produce a result in accordance with these formulas. After these standard formulas have been developed, research planning must constantly be in progress to improve these standards, and in addition, to the development of new formulas preparatory to producing new products which may have an economic value.

In these industries, the function of technical planning must also include the function of testing. This function must be in close co-operation with the main functions of purchasing, operation and sales. Purchases must be made in accordance with the specifications made by the planning department. When the material arrives, tests must be made to ascertain whether or not the material received complies with the purchase specifications as to quality. During the process of operation, tests must be made at the various stages, to determine how closely the function of operation adheres to the instructions of the planning function. Before a product is placed in charge of the sales function, tests must again be made to assure that the product conforms with the sales specifications.

A general analysis of the management features of chemical and metallurgical industries has shown that many of the weak points are the result of the insufficient development of the operation branch of the planning function. To promote sound management, it is equally important to have definite, standard methods of operation planned in advance. These plans must be made by persons especially fitted for this class of work, and not left entirely to the judgment of the foremen or gang bosses in each department. Because in the past this feature has been left to the judgment of each de-

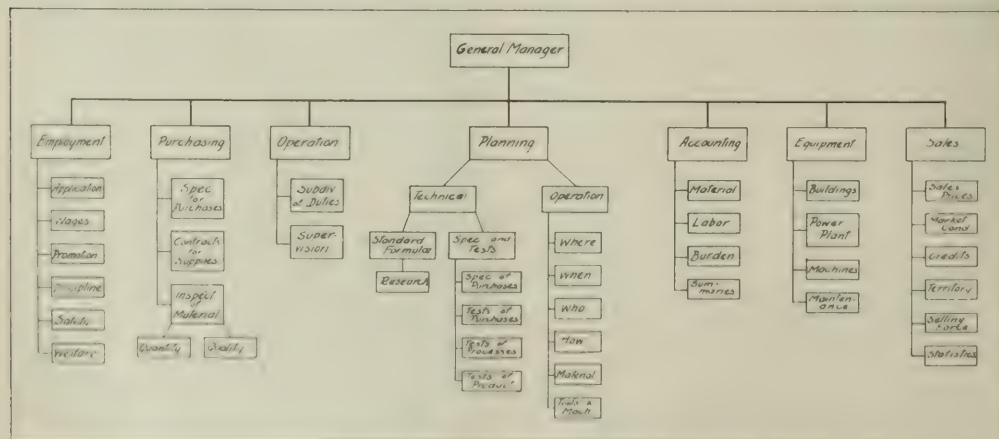


FIG. 1—FUNCTIONS OF ORGANIZATION

partment head, a great unevenness in the operation features of the different departments has developed, and rule-of-thumb methods are in vogue rather than scientific methods.

Importance of Time Element

All other things being equal, the efficiency of an operation is dependent upon the speed of the operation; in other words, the time element is of great importance. Assuming the quality to remain the same, the cost of an operation decreases as the time decreases. Hence the problem of importance in cost reduction work is the problem of time reduction. Since time is such an important feature, an analysis of the time required to perform each operation is necessary. The most scientific method of time analysis is by means of the decimal stopwatch, and by what is known as elementary time-study. According to the elementary time-study method, the total or over-all time of an operation is not taken as such, but each operation is divided first into its elementary component parts and the time of each element obtained. In the analysis of an operation by this method we find, in most instances, that a number of the elements are avoidable and can be eliminated. After all unnecessary elements are eliminated, a new cycle of elements of least waste is synthesized from the data sheet, and this new cycle of elements, or motions, is taught to the workers. This is the basis of all time-study research work and it is by this method that so many astounding results have been produced in almost all industries and in almost all classes of operations. It is from these data that standard operation instructions are issued and on which the incentive wage-payment methods are based. It is this standard time on which operation efficiencies are based.

In the chemical and metallurgical industries, however, we find a large number of process operations in which

the time element is beyond the control of the operators. On such operations, the important feature, from a labor standpoint, is the strict attention to the instructions which govern the operation of the process. The process operation must be closely supervised, otherwise the product will be inferior to the standard requirements. In such cases, the incentive wage payment method is not based on the time reduction, but on the strictness of the regulation of the process, which governs the quality of the product. For example, in a certain instance, the quality of the product of a process was governed by the specific gravity of the mixture during the operation. To insure high quality of product, a specific gravity was necessary which was not allowed to fluctuate beyond certain fixed limits. Periodic tests were made each day. On each day that these tests indicated that the specific gravity was kept within the limits, a bonus was paid to the operators. In this instance, the efficiency of the operating force was measured by the fluctuation in specific gravity.

Methods Which Tend to Increase the Efficiency of Each Function or Sub-Function

As stated previously in this article, in order to determine the status of any organization, a comparison of principles which now exist should be made with the fundamental principles and laws of management which we know hold true for any industry. These laws or principles of management have been stated in somewhat different form by various authorities, but a comparison and analysis of the statements of the various authorities shows that fundamentally their ideas are the same. The difference is merely a difference in the form and completeness of the expression of their principles. We are all more or less familiar with what Taylor calls the "Principles of Scientific Management," Emerson the

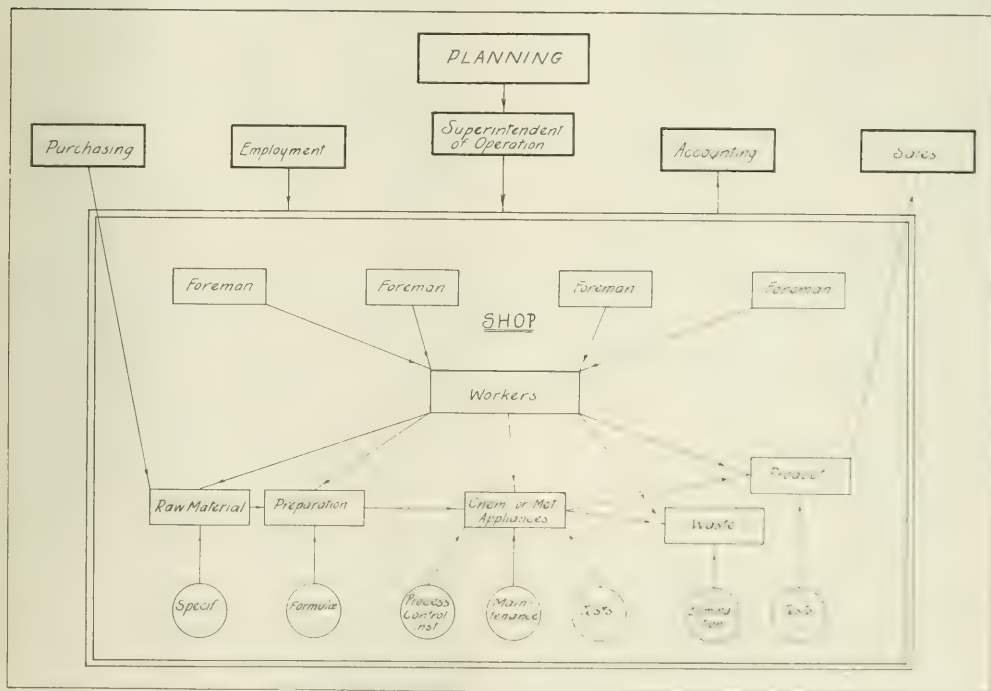


FIG. 2—FUNCTIONS OF OPERATION

"Twelve Principles of Efficiency," Gillette the "Laws of Management," etc. These principles, or laws, are of great aid in the visualization of the problems of management and in the critical analysis of present conditions. Each law or principle should be thoroughly studied, and then an analysis made of the present organization, so as to determine if each of these laws, or principles, is recognized and applied in the present organization to the fullest possible extent.

The above laws apply, in general, to an analysis of the human element of industrial work. The material element must be analyzed somewhat differently, but definite laws also have been formulated to analyze these problems. In order to give a concrete example of analysis and application, the function of material or stores will be used as an illustration. It is believed that the method which follows is applicable to any and all forms of industrial organizations where materials are in use.

Analysis of Problems Which Relate to Materials

The laws which relate to materials are stated by Duncan as follows:

1. Materials must be purchased from the lowest priced firms when materials are at their lowest prices.
2. Materials must come up to their contracted excellence in quality.
3. The quantity purchased must be obtained.
4. Materials must be delivered at the specified time.
5. Materials must be properly housed and stored.
6. There must be no unnecessary waste of material.
7. No losses must occur except through waste.

Now that we have a definite basis with which to study the material problem, the next step is logically the development of functions and a mechanism to insure that these laws are carried out. If we study these laws it will be seen that laws 1 and 4 arrange themselves naturally under one function, that of purchasing, which means that in order to live up to these two laws, we must have a well organized purchasing department.

Laws 2 and 3 deal with the function of inspection, and hence the organization of an efficient receiving and testing department should commence to insure the proper fulfillment of these laws.

Law 5 circumscribes the physical conditions which surround materials when once received and leads to the establishment of a proper stores system with accurate accounting.

Law 6 refers to wastes of issuance, and hence an adequate control system of issuance must be designed which fixes responsibility.

Law 7 refers to losses of maintenance of materials while in use and during the action of placing them in use. The function to safeguard such losses is a function of maintenance, and hence the establishment of a maintenance department becomes necessary.

We now have in view the establishment of five functions to insure the enforcement of the seven laws, namely:

1. Purchasing department.
2. Receiving and testing department.
3. Stores department.
4. Issues and reports.
5. Maintenance department.

The next logical step will be to design and introduce a mechanism for each function, so that the laws which pertain to that function are automatically enforced. Although the laws are constant for any industry or any condition, the mechanism with which to enforce these laws will vary with each problem; in some instances a very simple mechanism may be a safeguard, while in other cases a complex mechanism must be designed. The following covers certain points in the design of

any mechanism which should be given careful consideration. It is not the object of this article to discuss these in detail, but they are only intended to serve as a guide.

PURCHASING DEPARTMENT:

- a. Catalog files.
- b. Price lists.
- c. Special quotations.
- d. Economic amounts to purchase.
- e. Book of standards.
- f. Purchased orders with promised delivery dates.
- g. Reminder file.
- h. Efficient filing system.

RECEIVING AND TESTING DEPARTMENT:

- a. Quantity tests by receiving clerk.
- b. Quality tests by inspector.
- c. Notification that goods have been received.

STORES DEPARTMENT:

- a. Properly arranged warehouses.
- b. Stock piles.
- c. Standard bins.
- d. Mnemonic classification.
- e. Stores records (perpetual inventory).
- f. Maximum quantities.
- g. Minimum quantities.
- h. Bin tickets.
- i. Checks.

ISSUES AND REPORTS:

- a. Requisition issue.
- b. Budget method.
- c. Extraordinary expense method.
- d. Unit record of consumption.
- e. Special accounting methods.
- f. Graphic charts.

MAINTENANCE DEPARTMENT:

- a. Prevent loss by misplacement or theft.
- b. Prevent deterioration.

In addition to the physical aspect of the material problem, we must contend with the human factor. A considerable part of the waste of materials is directly chargeable to the human factor. Certain definite laws should be followed to reduce this waste, and the following laws will serve as a guide in an analysis of these wastes: In order to reduce wastes of material due to the human factor, we must have:

1. All work carefully planned in advance.
2. Specifications as to the best materials and tools to be used.
3. Carefully drawn instructions of how to use and apply the tools and materials.
4. Materials and tools must be delivered to the worker in the standard condition specified.
5. Competent instructors to teach and aid the worker to follow these instructions.
6. Individual records of each worker as to results.
7. Extra pay when work is carried out as per instructions.

The Effective Growth of a Function

The preliminary plans of any industrial enterprise, or function of such an enterprise, are based on a knowledge of past attainments, that is, on experience. The men who commence a successful undertaking, have, in general, a knowledge of what has been done in that field of endeavor and how it has been done. This knowledge is the basis of the building up of a function, and the development of a routine for carrying on the work of a function. Hence the starting point is to accumulate experience. The first experience accumulated consists generally of the knowledge gained by personal work, or contact in the past with work, relating to that particular function. The second is experience gathered from the outside, what other industries of a similar nature have done or are doing, data from technical publications, and consultation with experts in that particular field.

This is the era of specialization. The average industrial enterprise consists of many functions, and it is impossible for one man to accumulate, classify and apply all the experiences of every function. This is the strongest argument for the staff type of organization, which has replaced the line type in many industries. In the staff type of organization, the functions are dis-

tinctly separated, and at the head of each function there is placed an individual or a staff, whose duty it is to become an expert in this particular function only. His authority and work does not conflict in the least with that of another function, and he is responsible for the work of his function to the general manager only, and to no one else. An enormous amount of experience is now available in any function, and if an individual is made responsible for one function only, he will have time to gather a wealth of experience in this function; and similarly the heads of all other functions. As a result, the enterprise as a whole will have at its command a large bulk of accumulated experience on which to base its plans and policies.

After experience has been accumulated, the next step will be the standardization of this experience, so that it can be successfully applied. This process of standardization consists of an analysis of the data obtained, and from this analysis to build up, or synthesise, a working method particularly applicable to the local peculiarities of the function involved. Carefully drawn plans, based on definite standards, are one of the greatest waste-elimination tools.

The third step consists in the application of this accumulated and standardized experience. During the process of application, the accumulation of further experience must be carried on as strongly as ever before. We accumulate considerable experience of our own during the process of application. This experience we may find to be similar to that which we have already gathered from other sources, and may not suggest new standards. In general, however, each case has its own peculiar local conditions, and details may develop from personal experience during the application, which are entirely dissimilar from anything of which we have a record, and may result in many improvements of standards. Therefore, the entire object is to establish definite standards, and then endeavor to improve these standards, by observation, assimilation, and application of further experience.

As we have seen that an industrial enterprise is divided into many functions, so an analysis of each function shows that it consists of various sub-functions; in other words, a further division of the work of each function becomes necessary. For example, in the operation function, under modern industrial conditions, we seldom find one individual or group of individuals perform all operations which tend to make a completed product.

The greater the number of functions and sub-functions, the greater will be the division of responsibility of the organization as a whole, and hence the next important principle to consider is that of co-ordination. Co-ordination is the control of division. As the work of each function must be so regulated that it will harmonize with the results of the work of the other functions, similarly the work of each sub-function must be so regulated and controlled, that the result will be a smoothly run organization mechanism as a whole. The greatest waste of improper co-ordination of work is that of time. Hence to improve and assure proper co-ordination a careful analysis should be made of the time required to perform the units of work of each sub-function and apply the data obtained in balancing the work. The knowledge of the time required to do the work, is really the basis of the proper division of the work, and again forcibly brings to our attention the importance of time-study analysis.

The growth of a function has now been traced from the accumulation of experience, its standardization and application, the division of work and the proper co-ordination of the divisions or sub-functions, so that at this

stage of the growth, the work of a function is supposed to be well balanced and regulated. The prime element of any industrial mechanism is the human element. It is the effort of the human element which carries on the work of the organization and assures that the industrial mechanism is kept in operation. To insure the proper and constant working of the organization, we must have proper conditions under which to carry on the work, reward this effort of the human element, and foster the growth of efficiency of this effort. In other words, we must promote personal effectiveness.

Personal Effectiveness

The study of the development of personal effectiveness is the most recent in industrial fields. The first division of this subject, which has been given considerable attention of late, is that which relates to the external conditions of the workers, or to the physical conditions of the surroundings of the workers. The divisions of this subject, which have been studied and applied to a greater or less extent in various industries, are enumerated below:

1. Atmospheric conditions:
 - Freshness of air.
 - Temperature.
2. Light:
 - Quantity.
 - Angle.
3. Quiet.
4. Freedom of movement.
5. Sanitation:
 - Cleanliness.
 - Brightness.
 - Appellances:
 - Latrines.
 - Washing facilities.
 - Clothes lockers.
 - Pure drinking water.
6. Safety:
 - Fire:
 - Sprinkler systems.
 - Fire drill.
 - Systematic inspection of emergency doors, stairways, etc., and of the alarm and fire fighting apparatus.
 - Machinery:
 - Surround dangerous parts in motion, with a protecting barrier. Place barriers around elevator shafts, openings in floors, etc.
 - First aid:
 - Properly drilled first-aid teams.
 - Medical service.
 - Emergency hospital.
7. Compensations:
 - Accident.
 - Sick and benefit funds.
 - Pensions.
8. Accessory conveniences:
 - Meal rooms.
 - Rest rooms.
 - Bath rooms.
 - Club rooms.
 - Libraries.
 - Etc.

The second part of the subject deals with the study and analysis of the inner qualities of the personnel of an organization. This involves the analysis of the special human faculties necessary to fill certain positions in the most efficient manner, and an analysis of the candidates for the position, as to whether or not they possess the required faculties. The pioneer in this field of endeavor is Professor Hugo Muensterberg, but to date so very little has been done in this field that it is as yet impossible to formulate any definite rules which would apply to all cases. It may be stated, however, that a great aid in the discovery of whether or not a worker is fitted for the work, is the knowledge of the best method and time for each job, and with these data as a base, shift the workers to such work as they can accomplish in the time set, and thrive under it. This has a very practical application in those industries which are now operated under scientific management. Records of performance of workers on various jobs are of great aid in the selection of workers for jobs. However, there are so many other elements which enter into this problem, that the field still has unlimited opportunities for research. We all realize that one of the great-

est wastes is caused by the physical and mental unfitness of workers for the work which they now perform, but at the present state of the development of the science, the solution of the problem is still faced with many difficulties.

After the surrounding conditions and the environments of the work have been so regulated as to foster the growth of personal effectiveness, and after the correct type of personnel has been selected for each type of work, the next step in the growth of personal effectiveness will consist of the development of that co-operative feature, which is commonly known as team-work. A study of the team-work of an organization comprises the analysis of the mass as a whole, and the mutual relations between the individuals which comprise this mass. The conscientious application of the principles of scientific management tends to promote this team-work. One of the simplest definitions of scientific management is "dignified team-work between employer and employee." Where the ideals and policies of an organization are of a high degree and compatible with the belief of a large majority of individuals, there is produced among the members of that organization what may be termed a group-pride. Individuals are proud to be members of that group, and group spirit is developed and fostered. The individual must have a firm belief and confidence in the leadership of the group and he must be impressed with the superiority of that group over other similar groups. The individual must have a firm belief in the purpose of the work of the group. There are numerous illustrations of this principle, such as racial pride, pride of nations, of fraternal organizations, of athletic teams, of universities, etc. When the spirit of the group is inculcated in the individual and each individual realizes that his effort aids in promoting the aim of the group, then we will have true team-work of the group. It is rather difficult to state just how this can be accomplished in every type of industrial organization, but justice, fair treatment, firm belief and confidence in the leaders, and recognition of effort are the main forces which will produce it.

Recognition of Personal Effort

Nothing will promote personal effectiveness more than will recognition of effort of the individual. The practical application of the recognition of effort in industrial organizations is the application of incentives or rewards proportional to the effort expended and the results produced. An incentive is that which incites, or tends to incite, to action. The part which incentive plays in the doing of all work is enormous. Incentives may be a definite or indefinite return of some kind. Punishment may incite action, but whether this action is detrimental or not, depends upon whether or not the right kind of punishment is administered. It has been noticed, however, that the greatest cause for cutting down work is related more closely to a reward than to a punishment.

Under industrial management, rewards are usually promotion and pay, the word pay including regular wages, bonus, shorter hours, or other forms of recompense. Punishment may be negative, that is no reward, or positive, that is, a fine, discharge, or shifting to less desirable work. In order to produce the greatest amount of incentive to action, rewards must be definite and positive gains to the individual. The individual must definitely know just what the reward will be before the work is commenced; that reward must be personal, *i.e.*, there must be a reward for that particular person for that particular work; the individual must get exactly what was determined before; the individual must be positively assured that he will get the reward; as soon as the work is done, the individual must get the reward.

These points must be kept well in mind in the design of wage systems. They also serve as guides in the analysis of existing wage systems. Only in so far as these points are adhered to, is the wage system highly efficient.

The number of different types of wage systems in use at the present time in industrial organizations are so numerous as to be beyond the scope of this article. They all, more or less, strive to adhere to the points enumerated, and their efficiency may be determined by the number of these points which they actually cover. Wherever possible, some standard wage system, which we know has been very effective in a number of cases, should be applied. However, in a great many of our industries, the conditions of work and kind of work are so varied, that it is almost impossible to apply one form of wage system successfully to all cases. Hence, some organizations have several different forms of wage systems in use. It may be found that due to local peculiarities of the work and labor conditions, it is impossible to apply any of the standard wage systems as a whole. This may lead to the design of a special system of remuneration especially applicable to the conditions involved. The principles pertaining to the effective growth of functions have been admirably stated by Church in what he terms the "Laws of Effort."

A Few Additional Points

As previously stated, the tendency of industrial organization is to organize according to the staff plan and this plan is replacing the line type in many organizations.

According to the staff type of management a complete classification of the work is made according to functions and an expert is placed at the head of each function who is responsible for the work of that function only. A sharp line of authority and responsibility is drawn.

It is a well recognized principle that the highest efficiency is obtained by the separation of planning from performing and this is brought about by the staff type of management. Although these lines may be drawn very sharply, theoretically, still there must be enough mobility and quickness of action so that emergency cases may be taken care of in the shortest possible time. A good manager is one who knows how and when to transgress from fixed methods of standard routine to take care of emergencies. A classification of all possible emergencies will serve as a guide to plan ahead definite methods of taking care of such emergencies and increase the rapidity of action.

One of the greatest emergency problems in any organization, is the sudden and unforeseen loss of some valuable member of the organization. A method known as the "Three Position Plan" is now in use by large and progressive organizations. According to this plan any member of the organization really holds three positions.

1. That of WORKER in his present position.
2. That of TEACHER to the member the next step lower in the organization.
3. That of STUDENT of the position the next step higher in the organization.

A chart is then drawn which indicates definite lines of promotion. Such a chart acts as an incentive to all members of the organization. A rule is also made that no member is promoted to the next higher position until his understudy is capable of filling the position.

In designing the lay-out of an organization, what is termed the "Exception Principle" must also be kept well in mind. This, briefly stated, is as follows:

1. Sub-divide work in such a manner that no high-priced employee performs work which can be performed by a lower priced employee.

2. Exceptional cases only should be brought to the attention of the higher officials.

The application of this principle involves the standardization of work and the determination of limits. As long as work is normal, the higher officials need not worry. However, as soon as the work, or results, pass out of the fixed limits the attention of the higher officials is automatically brought to this divergence from the normal.

Another valuable principle is stated by Mr. H. L. Gantt as follows:

"The authority to issue an order involves the responsibility to see that it is properly executed."

According to Mr. Gantt, adherence to this principle eliminates that class of managers, unfortunately too common, who like to shift the responsibility for their errors to their subordinates. By the elimination of such men, authority gravitates slowly, but surely, to those with knowledge, and we finally have a condition on which authority is based on knowledge and ability to use that knowledge. In other words, orders are given to accomplish results, and they should be given only when results are possible; in such a case no excuse for failure should be accepted.

In conclusion, it is only by the proper subdivision of work, effort and responsibility, the training and developing of leaders in each function, and the proper co-ordination of the work in all functions, that we obtain true and lasting industrial efficiency.

Benedict, Boyle & Stronck,
Chicago, Ill.

Apparatus Exhibit.—The L. E. Knott Apparatus Company, of Cambridge, Mass., will hold an exhibition at the opening of its new building during Thanksgiving week. The company makes a specialty of American made laboratory apparatus and has recently secured the agency for electric furnaces, hot plates and pyrometers manufactured by the Hoskins Mfg. Co., Detroit, Mich. Invitations have been issued to all the schools and colleges in the vicinity to attend the exhibition and a general invitation is extended to the public.

Soapstone.—In the production of soapstone the United States ranks first among all countries, and Virginia produces about 20 times as much as the four other producing states—Maryland, North Carolina, Rhode Island and Vermont. The waste from breakage in quarrying, sawing into slabs, manufacturing and final transportation is so great as to render success in the industry a matter of skillful manipulation. The value of the stone is in large measure proportionate to the work done upon it. In the rough it is valued at \$2 or less a ton, but when sawed into slabs its value is increased to about \$15, and when made into laundry tubs it may attain a value of about \$30 a ton. The production of soapstone and talc in the United States is steadily increasing, according to the United States Geological Survey, Department of the Interior. In 1900, it was 27,943 short tons, in 1910 it was 150,716 tons, and in 1915 it was 186,891 short tons.

Artificial Gas.—The quantity of artificial gas—oil and water gas and coal gas made at retorts and by-product coke ovens—marketed and sold in 1915, was 266,204,248,000 cubic feet, valued at \$173,832,132, according to statistics collected by C. E. Leshner, of the United States Geological Survey, Department of the Interior. This was an increase of 25 per cent in quantity and 17 per cent in value, compared with 1912, the next preceding year for which the statistics of this industry were collected by the Geological Survey.

The Processes of the Organic Chemical Industry as Used in the Manufacture of Intermediate Products

By A. H. Ney & D. J. Van Marle
Reductions

When in a chemical reaction oxygen is eliminated, hydrogen added, or oxygen replaced by hydrogen, this reaction is called a reduction. As an example of the elimination of oxygen without the addition of hydrogen, the reduction of nitrobenzene to azoxy and azobenzene will serve, whilst notable cases of the addition of hydrogen without other change in the molecular composition are the reduction of quinone to hydroquinone by means of sulfur dioxide, and of oleic acid and triolein to stearic acid and tristearin by means of hydrogen in the presence of reduced nickel—this latter reaction forming the basis of a large and growing industry.

The most important reductions from the technical standpoint, however, are those of the third class in which oxygen is both eliminated and then replaced by hydrogen, the chief class of bodies in which this reduction is commercially practised being the nitro-compounds, which are thereby converted into amido-compounds, the oxygen in the nitro-group being replaced by hydrogen. This reduction of nitro-compounds does not take place at once, but a number of intermediate products are formed, depending on the conditions during the reduction, all of which are ultimately converted into the amido-compounds.

In an acid medium first the nitroso-compound is formed, then the hydroxylamine-compound, but these intermediate products are reduced so quickly that they cannot be detected in the mixture. These two compounds also can react together and form an azoxy-compound, which on further reduction gives an azo-compound, then a hydrazo-compound which in acid medium is also reduced to the amido-compound.

In an alkaline medium, however, especially when zinc is used as a reducing agent, the reduction does not go so far and the hydrazo-compound is formed besides a small amount of the amido-compound.

The hydroxylamine-compounds, which also are of importance, can be obtained by reduction with zinc in neutral solution or concentrated sulfuric acid, and are converted by acids into para-amido-phenols.

All the intermediate products mentioned can be prepared by electrolytic reduction of the nitro-compounds, but as the necessary apparatus is complicated, and as they can be obtained also in a different way, the electrolytic way of preparation has not found any technical application, even if it has the advantage that the products have not to be separated from any reducing agents.

The intermediate products therefore do not interfere with the result of the reduction, which yields one definite reduction product, when starting from a pure nitro-compound. We only obtain a mixture of different products when we start from a mixture of nitro-compounds, as is done for instance in the case of the naphthylamine-sulfonic acids, which are made by nitration and reduction of the crude mixture, resulting from the sulfonation of naphthalene.

The reducing agents used on a large scale are iron, zinc and sodium-sulfide, others being too expensive. For a few preparations tin is used, and in such cases the tin has to be recovered.

Iron is used for the manufacture of amido-compounds directly from nitro-compounds, in the presence of an acid, either hydrochloric or acetic acid.

If the reduction were only effected by the hydrogen formed from the iron and the acid, a large quantity of acid would be required, whereas in practice only 2 to 3 per cent of this quantity is used. The reason is that a ferrous salt is formed, which itself is a reducing agent and which is converted into an oxychloride if hydrochloric acid is used. This oxychloride is acted upon by the iron, forming black iron oxide, while at the same time ferrous chloride is regenerated, which can reduce another quantity of the nitro-compound, the hydrogen necessary for the preparation of the amido-compound being supplied by the water, and in case acetic acid is used a reaction of similar nature takes place. This not only saves a large amount of acid, but also makes it possible to carry the reaction out in iron reducers, as the solution of ferrous chloride is only slightly acid and therefore does not corrode the apparatus. The amount of acid cannot be reduced any further as then the reduction would become so slow that too much time would be lost.

Where iron is not suitable it can be replaced by zinc dust which is used for the reduction of certain nitroso-compounds, amido-azo and oxyazo-compounds, which are converted into amido, diamido-compounds and amido-phenols, respectively, but here it is not possible to use such a small amount of acid. Examples are the reduction of nitroso-dimethylaniline to dimethyl-para-phenylenediamine, of amidoazobenzol to para-phenylenediamine and amidoazotoluol to para-tolylene-diamine. Of much more importance, however, are the reductions with zinc-dust in alkaline solution, when hydrazo-compounds are formed as the main product of the reaction. These hydrazo-compounds are converted into diamido-compounds of the benzidine class by boiling with acid, which discovery has led to the development of the large class of azo-dyes which can be dyed directly on cotton. The three products of this class of the most importance are benzidine, toluidine and dianisidine, made from nitrobenzol, ortho-nitrotoluol and ortho-nitro-anisol.

In a few instances sodium sulfide has found application. It has the peculiarity of reducing only one nitro-group in dinitro-compounds, so that starting from dinitrobenzol we can obtain with iron meta-phenylenediamine, and with sodium sulfide meta-nitraniline. It has been found that in case other groups are already present, the nitro-group in ortho-position to a hydroxyl-, amido-, chlorine- or oxy-methyl group is reduced, and the one in para-position to a methyl- or carboxyl-group, the other of the two groups being protected.

The temperature is a factor of small importance, most reductions being carried out at 80 to 100°C. The reaction is started with only a small quantity of both the nitro-compound and the reducing agent, which are heated together. As soon as the reduction begins, both products are gradually added, and the heat which is developed then is sufficient to keep the reaction going. If too large quantities were put together, so much heat would be generated that even an explosion might follow. It is therefore advisable always to have the reducing agent present in excess, so that the nitro-compound never can accumulate, and the reduction is entirely controlled by the adding of the nitro-compound. The only reason that not all the iron or zinc is put in at once is that this would mean a great strain on the agitator, and more power would be required for the agitation than necessary. The factors which determine the result of a reduction are therefore quite different from those in the case of a nitration. Whereas in the latter case the

result depends on the amount of nitric acid used and is otherwise pre-determined by the nature of the product to be nitrated, in the former we obtain different results by the choice of the reducing agent, and of the medium in which the reduction is carried out.

Application

The amido-compounds in their relation to the nitro-compounds and raw materials, from which they are produced, have been already described in the chapter on nitrations. Their largest application is found in the manufacture of azo-dyes, due to the property they have of forming diazo-compounds with sodium nitrite in acid solution, which can be combined with amido- and hydroxyl-compounds, which are generally designated as azo-compounds.

On account of the large number of combinations which can be made, the azo-dyes form the most numerous class of dyes, several hundred of them having found application, for azo-dyes can consist of more than two compounds, which increases the number of possible combinations enormously. When a diazo-compound is combined with an azo-compound first an intermediate product is formed, which in many cases, where the combination takes place slowly enough, has been isolated. With an amido-compound the combination takes place between the nitrogen atoms of both compounds, forming a diazo-amido-compound which later by intermolecular rearrangement is converted into an amido-azo compound. With a hydroxyl compound the combination takes place so quickly that the intermediate product cannot be isolated, and the oxy-azo-compound is formed immediately, but there is little doubt that it is formed, and in one case, that of beta-naphthol-ortho-sulfonic acid its existence has been proved. In all azo-dyes the azo-group is placed either in ortho- or para-position to the amido- or hydroxyl-group of the azo-compound of which the para-position is preferred, the two classes being distinguished as ortho- and para-azo-dyes. Ortho-azo-dyes, which have generally more desirable properties, can therefore only be formed when the para-position is already occupied. The para-oxy-azo dyes are of little value as they are not fast to acids, but the para-amido-azo-dyes are valuable, as they contain an amido group which can again be diazotized and combined with another azo-compound.

The first class of azo-dyes are the mono-azo-dyes obtained by combination of a diazo-compound with one azo-compound, the simplest being amido-azo-benzol or aniline-yellow, made by diazotizing aniline and combining the diazo-compound with aniline. It is a para-azo-dye and therefore of little value as a dye, but it is used as an intermediate product for the more complicated azo-dyes. From toluidine, xylylidine and alpha-naphthylamine similar compounds can be prepared, while the one from diazo-benzol and alpha-naphthylamine has also found much application.

The most important dyes of this class are made with sulfonic acids of the naphthalene-series, which on account of their acid nature have generally found application as wool-dyes, and only in a few cases are applied to cotton with a mordant, but these are mostly replaced by others with more desirable properties. To this class also belong a number of dyes, used as lakes and pigments, mostly containing beta-naphthol as the azo-compound. Of these para-nitraniline-red made from diazotized para-nitraniline and beta-naphthol has the largest production, and is used both for cloth-printing and for paints in enormous quantities. To dye it on cloth directly it is necessary to

prepare the dye on the cloth, which is done by first treating it with an alkaline solution of beta-naphthol, and then with the diazotized para-nitraniline.

The disazo-dyes contain three compounds, and can be subdivided in three groups. The primary disazo-dyes, which are made in one operation and can be prepared either from one diazo-compound with two azo-compounds or from one azo-compound with two diazo-compounds. For the first group it is necessary that the diazo-compound contain two amido-groups, which are both diazotized, and as both groups combine with a different speed, it is possible to combine it first with one, then with a second azo-compound. Benzidine, tolidine and dianisidine have this property, which has led to the development of one of the most important classes of azo-dyes, and as they have in addition the property of dyeing cotton directly, they are generally known as direct cotton dyes.

With para-phenylene-diamine this is not possible, but here we can obtain the same result by first preparing a mono-azo-dye from acetyl-paraphenylene-diamine, and saponifying it, or by reducing a dye made from para-nitraniline and re-diazotizing this dye, which now contains an amido-group, and combining it.

A number of azo-compounds, like alpha-naphthol, resorcinol and meta-phenylene diamine are able to combine with two diazo-compounds, as are some of the amido-naphthol-sulfonic acids, especially H. Acid. These acids contain both an amido- and a hydroxyl-group, and when we first combine in acid solution the diazo-compound will enter in ortho-position to the amido-group, while entrance in ortho-position to the hydroxyl group is prevented by the acid, after which we can combine this intermediate product in alkaline solution, the diazo-compound now entering in ortho-position to the hydroxyl group.

The secondary disazo-dyes are made in two operations, first a para-amido-azo dye being prepared, which is rediazotized and again combined. The most frequently used amido-azo-dyes are amido-azo-benzol, amido-azo-toluol and their sulfonic acids and those containing alpha-naphthylamine, Cleve's alpha-naphthylamine-sulfonic acids and Gamma acid, as middle components.

It is obvious that the disazo-dyes containing an amido-group can be diazotized again, thus leading to the trisazo- and tetrazo-dyes, which are still more numerous, but of which fewer have found application. Often these trisazo-dyes are formed on the fibre, after the cloth has been treated with the disazo-dye, thereby giving it a more desirable shade or a greater fastness. The amido-azo-dyes in this case are diazotized on the fiber and combined, mostly with beta-naphthol, meta-phenylene-diamine or meta-toluene-diamine; the oxy-azo-dyes are developed on the other hand with a solution of diazotized para-nitraniline.

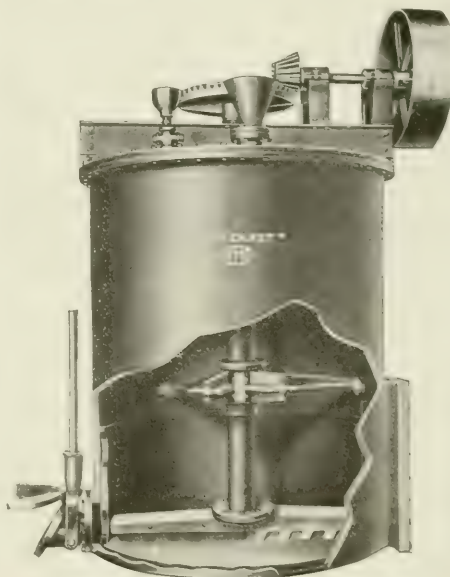
The amido-compounds often are converted into other intermediate products. Aniline is the most important, and besides being used in large quantities in the rubber industry is the starting material in the production of amido-azo-benzol and its sulfonic acids, dimethylaniline, nitroso-dimethylaniline, diphenylamine, acetanilid, para-nitraniline, para-phenylene-diamine, sulfanilic acid, hydroquinone and a few other intermediate products of minor importance. Large quantities are also used for aniline-black dyeing, the aniline being oxidized with bichromate of soda, and for the production of a number of other dyes, such as fuchsine, aniline blue, induline and nigrosine.

Of the toluidines, ortho-toluidine is used in the manufacture of amido-azo-toluol, safranin and sulphur-blues, para-toluidine for para-fuchsine, aniline-blue and primuline-dyes.

Metanilic acid, when fused with caustic soda, is converted into meta-amido-phenol, the base for the Rhodamines, which are important silk dyes. Anthranilic acid or ortho-amido-benzoic acid once was of importance in the preparation of synthetic indigo.

In the naphthalene-series alpha-naphthylamine and its sulfonic acids are most valuable, both in the manufacture of azo-dyes and as intermediate products in the production of alpha-naphthol and its sulfonic acids and the amido-naphthol-sulfonic acids. The sulfonic acids of alpha-naphthylamine are partly obtained by direct sulfonation of alpha-naphthylamine, as is naphthionic acid, and partly by reduction of the nitro-naphthalene-sulfonic acids. In the last case mostly a mixture of different acids is obtained which can be separated by their different solubilities, often not without difficulty. Beta-naphthylamine and its sulfonic acids on the other hand are prepared in an entirely different way by heating beta-naphthol and its sulfonic acids with ammonia under pressure.

The field of application of amido-compounds and their derivatives extends also in other directions besides the dye industry. Among medicinal compounds, for instance, such synthetic antipyretics as acetanilide, phenacetine, triphenine, phenocoll, neraltene and antipyrine, and the cocaine substitutes, anæsthesine and novocaine, all contain amido or imido groups which have been formed by reducing nitro-groups at some stage in their manufacture. The final step in the production of the valuable antiparasitic salvarsan is also a reduction, the reducing agent in this case being sodium amalgam, whilst the products pyramidone and trigemine, which have useful analgesic properties, and are manufactured from antipyrine as a starting point, obtain their extra amido group by the reduction of a nitroso group by means of sodium sulfide.



1600-GALLON REDUCER

Many amido-compounds, which also contain one or more hydroxyl groups have the feeble reducing power necessary to change silver photo-halides to metallic silver, and hence are used as photographic developers. Most of these have one amido group only, such as rhodinal or para-amido-phenol; metol, its methyl compound; edinol or para-amido-saligenine; glycine or para-oxyphenyl-glyccol; ortol or ortho-methyl-amido-phenol and eikonogen or 1.2 amido-naphthol 6 sulfonic acid, while a few like amidol or diamido-phenol and diphenal or diamido-oxydiphenyl contain two amido groups, and they are all formed by the reduction with a suitable reducing agent of the corresponding nitro-compounds.

Apparatus

The apparatus in which a reduction is carried out is a reducer, preferably built of cast iron, which need not be jacketed as all reductions are done in the presence of water, and therefore the mixture can be heated very simply by blowing in live steam. To protect the reducer against the action of the iron borings, which are stirred around, the inside of the kettle at the bottom is lined with cast-iron plates, which can easily be replaced and the presence of which therefore prolongs the life of the kettle. The agitator has the shape of a rake which almost touches the bottom and which moves the iron around sufficiently to prevent it from caking, while it also keeps the iron oxide suspended in the liquid. This oxide when once allowed to settle forms a cake which it is impossible to stir up, so that if the agitator is stopped for a sufficient length of time it is impossible to start it up again and the reducer has to be cleaned before the reduction can be finished. As many nitro- and amido-compounds are volatile with steam and also have poisonous properties, it is advisable to have the reducer covered, and where the volatility is great it is necessary to have the escaping vapors condensed and the condensate returned to the reducer.

Both the iron or zinc dust and the nitro-compound are put into the reducer gradually, the first because the strain on the agitator would be too large if all the iron or zinc were added at once, the second because it is then easier to keep the reaction under control. Reducers are built as large as 1600 gal., this large size being mostly used in the manufacture of aniline, of which 2000 lb. can be produced in one operation.

When the amido-compounds are volatile with steam, as in the case of aniline, toluidine and xylydine, they are separated from the iron oxide by distillation with steam, allowed to settle in separating tanks and separated from the water mechanically. To obtain them in a state of sufficient purity they are distilled in vacuum, and the product obtained in this way are practically c.p. if the hydrocarbon from which they are made has been pure. As toluol at present is required in large quantities for the explosive industry and commands a high price, it pays the manufacturer of these hydrocarbons to separate them as completely as possible, and their purity therefore leaves nothing to be desired. Commercial toluidine is a mixture of the ortho- and para-toluidine which can be separated before the reduction. Commercial xylydine, however, is a mixture of five different xylydines of which meta- and para-xylydine are of the most importance and present in the largest quantities. From this mixture the meta-xylydine can be obtained by separating it out as the acetate, the para-xylydine as the hydrochloride after the meta-xylydine has been removed.

In most other cases the amido-compounds are suf-

ficiently soluble in hot water to keep them in solution and separate them from the iron oxide by filtration, after the iron in solution has been precipitated with soda-ash. On cooling, the amido-compound will crystallize out and can be purified by recrystallization or distillation in vacuum, but some of the products of this class are so soluble that the solution has to be evaporated to dryness. This is especially true of the alpha-naphthylamine-sulfonic acids and most often, as we have seen, a mixture of two sulfonic acids is here obtained, for the separation of which we make use of the difference of solubility of their neutral or acid salts or the possibility of one being precipitated by adding salt to the solution while the other remains dissolved. The hydrazo-compounds obtained by reduction of a nitro-compound with zinc dust are neither volatile with steam nor soluble in water and have to be separated from the zinc oxide by dissolving this carefully in cold dilute hydrochloric acid, the zinc thereby being recovered as zinc chloride.

Outside the reducer and the vacuum still therefore no specially constructed machinery is required in this operation. The wooden and iron tanks which are used here are of very simple construction, while the apparatus for the separation of solids and liquids, such as filter presses are of the common types.

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The Chemical and Physical Properties of Foundry Irons

By J. E. Johnson, Jr.

(Continued from page 537)

Silicon

Next to carbon, this is the most important component of cast iron. It varies in ordinary iron from 0.2 up to 4.0 per cent. Above 4.0 per cent the iron passes into the field of "silvery" iron, and from thence to ferro-silicon. It is extremely difficult to make iron containing less than 0.2 per cent silicon in the coke furnace without having the sulphur run up to prohibitive limits. In the charcoal furnace iron can be produced with silicon as low as 0.10, or 0.15 in good white iron. The lowest I have ever seen it was 0.03, but this was in the spongy white iron of which I have spoken above.

Various investigations have been made as to the effect of the addition of silicon to steel. Sir Robert Hadfield conducted an extensive research on alloys of iron and silicon several years ago; this can be found in the *Journal of the Iron and Steel Institute*, 1889, Vol. II, page 222. The effect of silicon on steel (and therefore upon the matrix of gray iron also, in a general way), within the ordinary limits in which it occurs in foundry iron, was not particularly marked, but when the silicon rose above 3.5 per cent it diminished the ductility of the steel materially. I have already pointed out that the strength of the matrix of gray iron proper is far less important than the extent to which it is cut up by graphite, and for this reason within ordinary limits we do not need to consider very seriously the relatively slight effect of silicon upon the metal itself (that is the matrix), but its effect upon the carbon. This, as is well known, is to force the carbon out of the combined condition into the graphite, and thus action takes place not only above the melting point, but also down to relatively low temperatures.

It is best illustrated by the fact that ordinary coke iron of more than 1.0 per cent silicon will not show a white chill when cast against a chill block. Under any ordinary circumstances, this silicon is sufficient to force the graphitization of the carbon, in spite of the sudden

cooling. Below this percentage the chilling power of the iron is roughly inversely proportional to the amount of silicon present. The iron begins to show a chill as cast from the furnace a little below 1 per cent. At 0.75 silicon it will show ordinarily $\frac{1}{4}$ in. of white chill, at 0.5 silicon $\frac{1}{2}$ in. chill, and at 0.25 silicon it will chill clear through a depth of 2 or 3 in., and will show much white in the pig, even when slowly cooled.

The completeness with which carbon is thrown out of the combined condition in unchilled iron is, in a rough way, similarly proportional to the silicon present. With 2 per cent silicon an ordinary coke pig iron will hardly show more than 0.25 per cent combined carbon, but the amount left in the combined condition will rise as silicon falls, until it may be as high as 1.0 per cent throughout the mass without the casting being chilled white on the surface, when the silicon goes down well below 1 per cent. These figures are subject to modification by considering half a dozen other factors besides silicon, and are correct only in a general way for average conditions. Definite figures are only given with great reluctance to avoid glittering generalities which sound well and mean so little.

Apart from this influence on the carbon, silicon, when it rises above 2 per cent, has the effect of hardening the matrix of the iron itself, so that an iron may be really harder to machine in consequence of having silicon added to it than it would have been with a somewhat smaller amount. There seems to be a certain probability, also, that the portion of the silicon burned out when the iron is melted in the cupola (about 0.25 per cent in ordinary practice) remains to some extent enmeshed in the iron, and gives rise to that bane of the foundryman's existence—"dirty spots"—in the casting. These, being in the form of silica or silicate of iron, are, of course, very hard, and vastly increase the difficulties of machining the casting which contains them, even though they may not be present in sufficient amount to cause the rejection of the piece.

The effect of silicon on the strength of the iron is, of course, very different in different portions of the silicon range. The amount which converts the iron from white to dense gray increases its strength by turning brittle and crystalline cementite into tough and homogeneous pearlite, even though the latter be somewhat cut up by graphite. But as the silicon content rises further and forces the combined carbon far below the pearlite ratio (say from 0.9 down to 0.2) it weakens the matrix and simultaneously increases the deposition of graphite and the size of its particles, interrupting the continuity of the structure, and in both these ways reducing the strength of the iron.

Sulphur

This is the most troublesome element in the metallurgy of iron. It is present in the coke with which irons are smelted, in amount from about 0.8 per cent up to 2 per cent. Probably in present practice it averages 1.10 per cent. Most of this is forced into the slag, but sulphur has an affinity for iron, and it is commercially impossible in coke practice to maintain the sulphur continuously much below 0.025 per cent in ordinary iron, and only down to that amount at excessive cost in coke and limestone over that required to hold it down to 0.04.

Charcoal is almost free from sulphur, and, therefore, irons with one-half this sulphur may be made with that fuel more easily than iron with 0.025 per cent can be made with coke. At the same time charcoal iron does not average below 0.018 and is seldom below 0.010. This matter has been subject to very wide misapprehension, which has been a hurt and not a help to charcoal iron. The low sulphur of charcoal iron has often been

claimed as its principal virtue. With sulphur contents claimed to be "a trace" or "under 0.01 per cent," the latter statement is totally erroneous, since the sulphur in practically all charcoal iron is twice the amount claimed, and is little or no lower than that of a great deal of coke iron, while the increase in sulphur in remelting in the cupola is so much greater than that in good iron of either kind that a far greater improvement as regards this element can, in general, be produced in the final product by a little more care in buying and analyzing the coke for the cupola, rather than the pig iron. The real virtue of charcoal iron is to be found in a totally different direction, as I shall presently endeavor to point out. Its freedom from sulphur gives charcoal the advantage which it enjoys in producing iron of higher quality than can be produced with coke, except by treatment after it leaves the furnace, but the low sulphur of the iron itself is not the reason for this superiority.

Sulphur forms with iron a sulphide which has an extremely low melting point, and this sulphide dissolves in the iron itself in varying proportions in such a way that the sulphur exerts a threefold influence: First, it tends to hold the carbon in the combined condition; second, it tends to liquefy out into segregated spots and, on account of its low melting temperature, sulphide of iron is extremely likely to bleed or run from the point which remains molten longest, and thereby cause a shrinkage cavity; third, it has an objectionable tendency to produce high shrinkage in the iron, with all the attendant difficulties of casting practice which accompany this condition.

Sulphur also has a very serious tendency to cause cracks in the iron, which is probably a result of the shrinkage. A white coke iron will often be high in sulphur, from 0.07 per cent up to 0.2 or 0.3 per cent in extreme cases. Such an iron, when quickly cooled with water, will crack up into little cubes like dice, each of whose faces is discolored almost black with a film of so-called "oxide color." White charcoal iron, on the other hand, of even lower silicon is tough and reasonably strong, and practically never shows this tendency to break up into small pieces with oxidized faces. This statement is important and will bear some emphasis. In making coke iron low in silicon "basic" we always expected to see these conditions if the furnace became somewhat cold. On the other hand, in charcoal practice extending over three years I never recollect to have seen a single case of this, although the charcoal furnace, with the quickness of its kind, was capable of getting into just as serious difficulties as the coke furnace ever did, and did so much more frequently. Conditions are so similar in other respects that it seems to me we must assume that this objectionable tendency to form cracks is due to the presence of sulphur. In the manufacture of chilled cast-iron car wheels the sulphur must be kept within certain limits at all hazards, as otherwise the wheels will crack under the thermal test.

For this poison in the iron we have as antidotes silicon and manganese. The silicon has no tendency to remove the sulphur, but, tending as it does to force the graphitization of the carbon, it resists the tendency of the sulphur to keep it in the combined condition. There is a rough-and-ready rule for the quantitative value of this effect, which is that 10 units of silicon are required to offset the effect of one of sulphur, so that, if the sulphur in the casting be raised 0.1 per cent, the silicon would require to be raised 1.0 per cent to offset the sulphur. It is almost certain, however, that, while the silicon prevents the action of the sulphur on carbon, it does not prevent its tendency to produce cracks and to increase shrinkage, with all its attendant evils.

The ordinary sulphur specifications for pig iron are 0.05 per cent for steel-making irons, and 0.04 or 0.035 per cent for foundry irons. For some special grades, for which a special price is paid, even lower limits are specified. When this iron is remelted in the cupola it always takes up some sulphur from the coke in the fuel bed; this amount varies from 0.02, in extra good practice, to 0.10 or even more, in bad practice, and, while I am not one of those who sneer at the foundrymen, it does seem that they are at times inconsistent, since many of them will make a violent protest if the sulphur in the pig is 0.01 per cent higher than the specifications call for, and will then buy a cheap coke which will raise it 0.05 per cent higher than would a really first-class coke.

I regard sulphur as the most objectionable element in cast iron with which we have to contend, and I believe the foundrymen are absolutely right in leaving no stone unturned to get the sulphur as low as possible in their castings, but sometimes it seems that they put the emphasis in the wrong place. In this connection, it may be said that the benefits in holding down the sulphur, which may be obtained by the use of lime and a little fluor spar to flux the ash and sulphur of the coke, are not as widely appreciated as they should be.

Phosphorus

The determination of the effect of phosphorus upon steel might almost be said to have been the first fragment of our modern knowledge of metallurgy. The readers are perhaps familiar with the story that after Sir Henry Bessemer's first successful production of steel on an experimental scale he licensed manufacturers to use the process, but when they came to do so the product was rotten and worthless. His process was condemned, and he himself was subjected to contumely for his claims. He set out to find by chemical analysis the reason for the failure, and discovered that it lay in the phosphorus content of the iron from which the steel was made, and that, by one of those curious tricks of fortune, he had bought for his experiments the only iron in England low enough in phosphorus to make good steel.

Once this was revealed, the ores which would produce iron of low enough phosphorus were located, and by using only these suitable iron for his process was obtained. With the exhaustion of the purer ores, the limit of the phosphorus set for Bessemer steel has gradually risen, until it is now about 0.09 per cent. Dozens of processes have been introduced for making good steel out of material containing more phosphorus than this without removing the latter, and it is said this may be done with some success so long as the carbon is low. When the carbon rises, however, such material always becomes brittle, uncertain, and unreliable. This has given phosphorus a bad name.

It has been assumed that because phosphorus was bad for steel it must necessarily be so for cast iron. Here again is found ignorance of that fundamental fact that a reduction of the strength of the matrix may be unimportant if a change in those conditions which affect its continuity is simultaneously made. Moreover, cast iron is a brittle material, and is not expected to be used in tension, or only under exceptional conditions, and there is no proof that phosphorus increases the brittleness of the metal until it reaches many times the limit permissible in steel. On the contrary, the Southern irons which carry in the neighborhood of 1.0 per cent phosphorus command a premium for foundry purposes.

The effect of phosphorus is probably due to the fact that it forms one or more definite compounds with iron,

which have a low melting-point, and which dissolve in the iron and lower the melting-point of the whole mass.¹ This is different from the effect of sulphur, in which the tendency seems to be for the last freezing portions to segregate after the major portion of material has solidified. The fact that phosphorus contributes to the fluidity of iron is well recognized, and for many classes of castings which require to be made very thin the phosphorus is run up to 1.0 per cent or more. There is probably little doubt, however, that this content is high enough to affect the strength of the iron adversely. For general purposes, where strength is more and fluidity less important, phosphorus from 0.5 per cent to 0.75 per cent is to be preferred—the latter being only for lighter castings, the former for heavier and stronger castings.

(Since the above was written, I find that the experience of the automobile manufacturers has been that phosphorus must be kept below 0.3 per cent in their extremely complicated and difficult cylinder castings, as more than this causes a slight ligation from the heavier parts of the castings to the lighter ones and produces porosity at the former points. Castings are more difficult to make with this low phosphorus content and have to be poured considerably hotter than would otherwise be necessary, but this is the only method by which porosity can be avoided. For the ordinary run of thin foundry work, where these very severe conditions do not have to be met, higher phosphorus facilitates the work greatly.)

The effect of phosphorus up to about 0.4 per cent seems to be to increase the strength of iron. Remelts which I have made in crucibles proved this conclusively. Two remelts were made of the same iron, to one of which phosphorus was added, raising it from 0.13 to 0.40, the other not being changed in any way. This was done on two very different irons with the same result in both cases. The strength of the best bars was materially increased by the addition of the phosphorus, and so were the depth and character of the chill. These are both most desirable qualities for material such as car wheels, but the knowledge that somewhere below 1 per cent phosphorus begins to make the metal brittle and treacherous debars us from going beyond very moderate limits in this direction for castings in which strength and reliability are the prime consideration.

Oxygen

I come now to that portion of my subject in which I fear my readers' credulity may be strained to the breaking-point. I have referred already to the investigation made at Ashland to determine the reason for the difference in quality of charcoal iron and coke iron. The first results of this investigation were those already described on the effect of high carbon, but, while these explained why some iron was bad, they did not explain why the irons of normal carbon were stronger than the coke irons of similar analysis, and in some cases very much stronger.

I went into the investigation with a profound conviction that, next to sulphur, oxygen was the worst enemy of cast iron, but, after several months spent in a vain endeavor to confirm this hypothesis, I suddenly conceived the idea that the presence of oxygen, and not its absence, was that which made charcoal iron superior to coke iron. Two years of research were required before sufficient proofs of this hypothesis to justify publication were secured, but these proofs were finally obtained and the results were published in a paper before the American Institute of Mining Engineers, under the title "The Effect on the Strength of Cast Iron Exerted by Oxygen,

¹J. E. Stead, "Iron and Phosphorus," *Journal I. and S. Inst.*, 1900, II.

Nitrogen, and Some Other Elements." The results of this investigation were at first violently combated by some scientific metallurgists, but are now being more and more accepted.

We found, first of all, that certain irons made when the furnace had been in trouble and working cold were exceedingly strong (sometimes, though not often, almost twice as strong as irons of practically identical analysis made at other times). We found that, after being remelted in crucibles, the strong ones retained and even increased their advantage in strength over the weak ones. We found, too, after months of trial, how to make oxygen determinations in cast iron; that the strong irons contained oxygen; that the weak irons contained little or none, and that those of normal moderate strength contained an intermediate amount.

By a curious coincidence, a very extensive thermal investigation of the action of charcoal and coke blast furnaces was being simultaneously undertaken for the purpose of bettering the fuel economy if possible. This investigation revealed the fact that furnaces which produce the strong irons are those which run with a deficiency of heat in their hearths and so tend to an incomplete deoxidation of the ore—that is, tend to leave a small amount of oxygen in the iron, while those furnaces which produce the weakest irons are those which generate the greatest excess of heat in the hearth and produce the metal at a temperature the highest of any above its melting-point, ending with the electric furnace, which develops practically all its heat in the hearth, and produces its iron at an excessively high temperature, this iron being the weakest of any variety of cast iron made. (See Figs. 10 and 11. Note the shape of the graphite and how it cuts the structure of the iron completely to pieces.)

Photomicrographs of different irons showed the reason for the increase in strength in the strong irons, since the graphite in these irons is relatively round and nodular compared with the graphite in the weak irons, which is thin and of tremendous extent, and cuts the iron like crooked knife strokes in all directions.



FIG. 10—UNETCHED. (MAGNIFIED 100 DIAMETERS.) ELECTRIC FURNACE IRON. NOTE EXTENT AND INTERSECTIONS OF GRAPHITE. STRENGTH OF THIS IRON VERY LOW, TEMPERATURE OF MANUFACTURE VERY HIGH. OXYGEN CONTENT ZERO

In Figs. 12 to 27 are shown strong irons and also weak irons of similar analysis, both before and after remelting. These figures are reproduced from the paper just mentioned. Figs. 29 to 33 show in particular an extremely nodular condition of the graphite, and indicate more plainly than can any words how much stronger these irons must necessarily be than those of similar composition containing thin, flaky graphite.

The experiments described in the same paper, and briefly referred to here, are only a selection from the multitude of experiments, all pointing to the same conclusion, carried on throughout the investigation mentioned.

It seems that the effect of the oxygen is fivefold:

First, it tends to throw the graphite into the nodular condition. The theory as to the action by which this takes place has not yet been fully confirmed by scientific investigation, but coordinates so many facts that I am satisfied it is correct, and feel justified in pointing it out here. Observation has convinced me that the irons which contain oxygen have a higher melting-point than those which do not contain it. When approaching the freezing-point, they do not freeze suddenly, as water turns to ice, but pass through a slushy or pasty stage, very different from that of hot-made coke iron. When graphitization begins in the latter it is still liquid, and the graphite forms from the liquid absolutely without any stress whatever upon it, and is therefore free to assume whatever shape it chooses, irrespective of how great the volume and surface of that shape may be.

But these oxygenated irons solidify at a higher temperature, at which little or no graphitization has yet taken place, and by the time they have cooled to the temperature of graphite evolution the iron matrix has become sufficiently solid to be the dominating element in the combination. The graphite forms, but forms only against the heavy pressure exerted by the pre-formed solid of the metal. In consequence, the graphite must form so as to take up minimum volume and surface. In other words, it must take this spherical form in which it is seen in Figs. 26 to 31.

A confirmation of this theory is that good charcoal

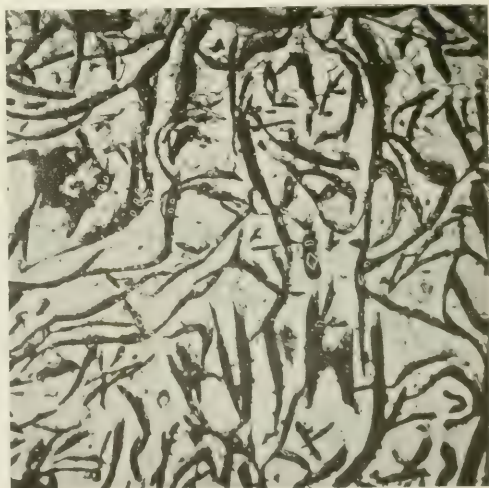


FIG. 11—ETCHED. (MAGNIFIED 100 DIAMETERS.) SAME AS FIG. 10. NOTE COMPLETE ABSENCE OF PEARLITE AND JOINTS IN FERRITE. THESE NEVER OCCUR IN OXYGEN-BEARING IRONS

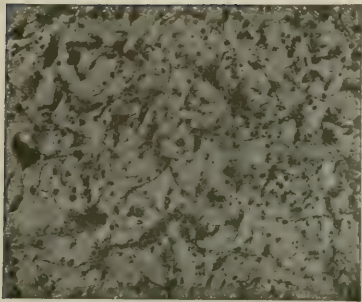


FIG. 12—UNETCHED

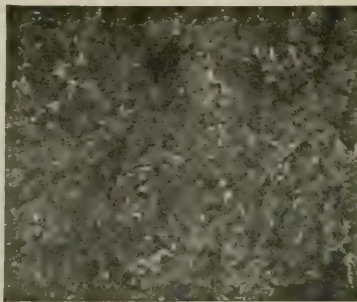


FIG. 13—ETCHED

(MAGNIFIED 100 DIAMETERS.) GOOD IRON. SILICON, 1.90; OXYGEN, 0.27 PER CENT
BREAKING STRENGTH, 1.25-IN. BAR, 3000 POUNDS, 3350 POUNDS

irons are noted for their low shrinkage, whereas bad ones are noted for their high shrinkage. This is, I believe, because when the graphite forms in the liquid, as it does in the oxygen-free irons, the iron then solidifies around it and after solidifying shrinks continuously until cold. But when the metal solidifies *previous* to the formation of graphite, the latter forms against the resistance of the metal, which results in an increase of volume of the latter after solidification, and this expansion is deducted from the total shrinkage in the final result.

This theory is not absolutely demonstrated as yet, but it is certainly in accordance with all the facts and is well worthy of an investigation, which I hope will be undertaken by some of the scientific metallurgists within a year or two so as to confirm or refute it.

Whatever may be the facts in regard to shrinkage, the increase in strength of irons which contain oxygen over those which do not contain it is a matter not open for discussion, nor is the shape into which it throws the graphite.

Second, the oxygen seems to exert another influence by changing the form of the crystallization of high carbon irons from that of the eutectic, previously shown in Fig. 3, to that of the mesh-work structure, shown in Figs. 5 and 6. By this means it increases the strength of the matrix, as well as diminishes the detrimental action due to the graphite.

Third, oxygen seems to act as a brake on the separation of the carbon and to prevent the hard and strong needles of cementite which exist above the last transformation point from breaking down into graphite

and ferrite, of which only the latter has any strength at all, and that much less than any other iron-carbon compound.

This action is clearly shown in Fig. 28, a photomicrograph of a coke iron of excellent reputation, exhibiting a number of long, slender plates of graphite with similarly shaped bodies of ferrite on one or both sides of them. These jointly constitute the remains of crystals of cementite by whose breaking down they were formed. The structure is obviously a weak one, not only on account of its shape, but because the graphite and ferrite are so much weaker than the original cementite.

This structure is never seen in irons containing any important amount of oxygen, for the reason that oxygen seems to prevent the breaking down of iron-carbon compounds to a point very far below the pearlite ratios of 0.9 per cent, such irons of moderate silicon ranging from 0.6 to 1.0 per cent combined carbon and seldom containing any visible ferrite.

I do not pretend to be able to explain this latter fact, but it is a fact in my own experience, nevertheless. The carbon range given, 0.6 per cent to 0.9 per cent, is that embracing the strongest steels, and this fact is undoubtedly of considerable influence in making these irons so strong.

Fourth, oxygen has an effect on a matrix itself, considered as a steel. This, as is known by the best-informed steel metallurgists, is that it strengthens the steel, but reduces its elongation and increases its brittleness. Undoubtedly the oxygen exercises the same influence on the matrix of the iron, but the results as regards brittleness are the opposite of what they are in steel, because nothing promotes brittleness so much as gashes in the material, such as are caused by flat flakes of graphite, and suppressing these not only increases the strength, but also largely eliminates what might be called incipient cracks, from which breakage might start; and this effect, therefore, reduces the brittleness of the metal far more than the slight effect on the matrix increases it. As a matter of fact, soft irons containing oxygen have not only greater strength, but also a degree of toughness amazing to those used to only ordinary cast iron; they seem almost to bend before breaking.

Fifth, oxygen exercises also a very important influence on the chilling power of the iron, due to its retardant action in the separation of the carbon, and it was undoubtedly for this reason that the use of high-grade charcoal iron was formerly almost universal for car wheels and remains accepted practice to-day for the production of those chilled castings which demand high quality and bring a high price. It seems to be a fact that

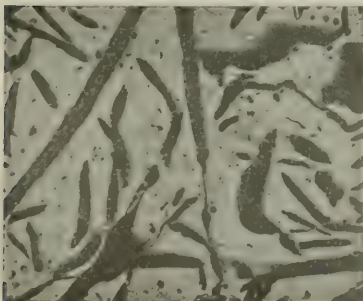


FIG. 14—UNETCHED

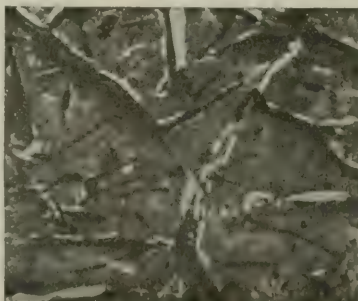


FIG. 15—ETCHED

(MAGNIFIED 100 DIAMETERS.) POOR IRON. SILICON, 1.88; OXYGEN, 0.009 PER CENT.
BREAKING STRENGTH, 1.25-IN. BAR, 2500 POUNDS, 2900 POUNDS

the presence of oxygen not only increases the chilling power of the iron, but also increases its sensitiveness to chilling influences. An iron containing oxygen, if cast in sand, will retain somewhat more combined carbon than a similar iron not containing oxygen cast under the same conditions, and if the irons are cast against a chilling surface the one containing oxygen will begin to show a white chill at a higher silicon than the other, and will continue to show greater chill for the same silicon as the latter element decreases all the way to the lowest limits.

Moreover, the character of the two chills is quite different. The chill of the oxygen-free iron is made up of needle-shaped crystals, or rather crystals shaped like long, slender pyramids, with their axes perpendicular to the chilling surface, their sides brilliantly polished, and making sharp angles with each other, so that the crystalline mass has but little strength in any direction parallel to the chilling surface. The chill of the oxygenated iron, on the other hand, shows crystallization normal to the surface. But these crystals, instead of being highly polished, have rough faces, so that they interlock with one another. The chill shades well into the gray at the base, the mottled area containing little stars of graphite in the field of white.

It is impossible to describe in detail, or even to show by photomicrographs, comparative chill structures, but those whose business is the manufacture of high-grade chilled castings have never ceased to use charcoal irons, even though they cost two to three times as much as coke iron of the same nominal analysis, for the reason that, with this iron, they have found by experience they can produce castings of a quality to justify their customers in paying the difference in price.

That the difference between charcoal iron and coke is in the carbon and oxygen I have described already, and in those two elements alone we have proved (so far as anything is capable of any absolute proof in so complicated a subject) by analyzing not only for all the common elements, but also the rarer ones and for gases such as nitrogen and hydrogen. Hydrogen we found to be absent, but nitrogen we found to be present in varying quantities, but no variation of the quality of the iron attributable to its variation could be observed, and, while we added nitrogen to the remelts by introducing nitrogenous substances, the differences produced even by considerable additions of nitrogen were unimportant.

Here, then, we find, as has so often been found before, that these curious, one might almost say mysterious, variations of quality arise not from variations of one element, but

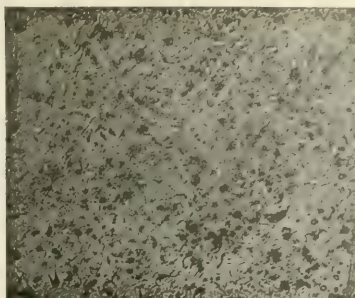


FIG. 16—UNETCHED

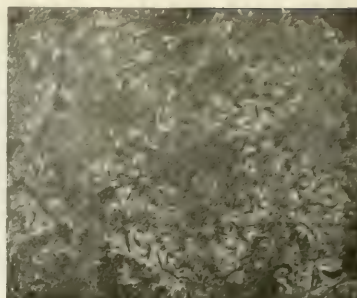


FIG. 17—ETCHED

(MAGNIFIED 100 DIAMETERS.) REMELT. SILICON, 1.90 PER CENT. BREAKING STRENGTH, 1.25-IN. BAR, 3150 POUNDS, 3200 POUNDS

from simultaneous variations of two. We have variations of carbon from well above to well below the eutectic ratio, with the resulting low quality in the first case; and we have, with this, variations in the oxygen whose presence results in greatly improved quality, whether with high or with low carbon. Considering the complexities of the operation of the blast furnace, the little that we have known until recently about its thermal equilibrium and the variations in the latter produced by different conditions of working, and the effect of these variations on the carbon and oxygen contents of the iron produced, it is not surprising that the variations in the quality of charcoal iron, as controlled by variations in the quality of charcoal iron, as controlled by variations of furnace practice, were so difficult of understanding as to seem positively mysterious.

The analysis of the thermal equilibrium of furnaces, to which I have before alluded, shows that those furnaces which produce good iron run with a relative deficiency of heat in the hearth, while those which produce bad iron run with an excess of heat in the hearth.

Observation both by eye and with the pyrometer shows that irons made under the latter condition are much higher in temperature as they come from the furnace than those made under the former, and this leads to two results—elimination of oxygen (which appears to be a function of temperature more than anything else) and super-carbonization of the iron, because while we know but little concerning the conditions which control the carbonization of iron, we do know that the degree of saturation possible increases with the temperature.

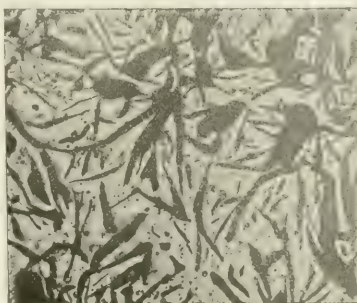


FIG. 18—UNETCHED

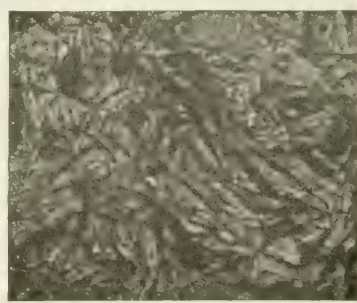


FIG. 19—ETCHED

(MAGNIFIED 100 DIAMETERS.) REMELT. SILICON, 1.88 PER CENT. BREAKING STRENGTH, 1.25-IN. BAR, 2600 POUNDS, 2700 POUNDS

We find, therefore, that those furnaces which work with excess of heat in the hearth tend to super-carbonization and to complete deoxidation, thereby lowering the quality of the iron, both by giving the weak eutectic structure to the matrix and by cutting it to pieces with large flakes of graphite.

In the case of cold blast charcoal iron, we have probably a modified condition of the enormous volume of carbon in the hearth tending to carbonize this iron more highly than normal, in spite of its low hearth temperature. We have here, then, a condition tending toward fairly high carbon, but also a condition of low temperature favoring high oxygen, and these are characteristic of iron produced by this process. The carbons are not excessive, ranging around 4 per cent in good, cold blast iron, while the oxygen is the highest in any standard variety of iron produced, ranging in such samples as we have analyzed from about 0.05 to 0.07.

These two facts are largely responsible for giving this iron its desirable characteristics, because the presence of oxygen seems to prevent absolutely the excessive graphitization of carbon, even when the carbon contents are high. This seems to be in line with the fact above mentioned, that oxygen exerts a general tendency in the direction of preventing the breaking down of the combined carbon into the graphite form.

Thus, with cold blast iron, we can secure the benefit of a large percentage of cementite in our chilled castings, without the danger of having this break down into graphite, as happens with carbon irons free from oxygen. We are able, therefore, to obtain extremely hard chill along with the extreme closeness of grain and the accompanying physical strength in the gray portion which oxygen brings.

Manganese

Manganese has been praised by many as a panacea for almost all the ills to which the foundry trade is liable, whether from too soft or too hard castings. On the other hand, it has been unhesitatingly condemned by many other able foundrymen as the basis of most foundry errors, particularly with chilled castings.

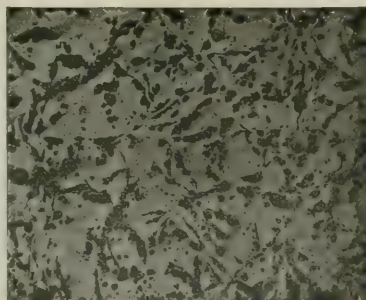


FIG. 20—UNETCHED

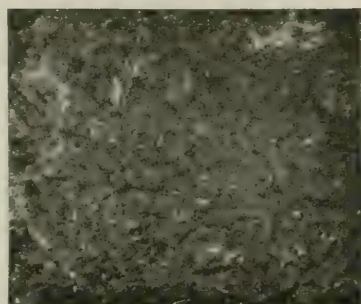


FIG. 21—ETCHED

The effect of manganese on steel has been exhaustively investigated (see "Manganese Steel," R. A. Hadfield, *Journal Iron and Steel Institute*, 1888, Vol. II), but, within the limits in which it is used in foundry practice, it is probable that we can largely ignore this effect on the matrix of the iron, on account of its more important collateral actions. These are important and are two or three in number, and it is certain that the effect of manganese, like that of silicon, undergoes a reversal after it exceeds a certain amount. Manganese has a greater affinity for sulphur than has iron. It is, in fact, a

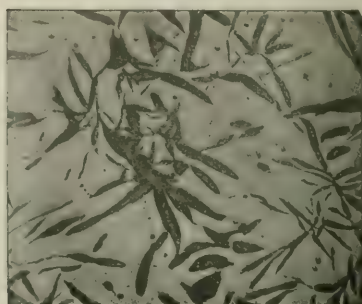


FIG. 22—UNETCHED

MAGNIFIED 100 DIAMETERS. GOOD IRON. SILICON, 0.70; OXYGEN, 0.065 PER CENT. BREAKING STRENGTH, 1.25-IN. BAR, 3500 POUNDS, 4200 POUNDS



FIG. 23—ETCHED

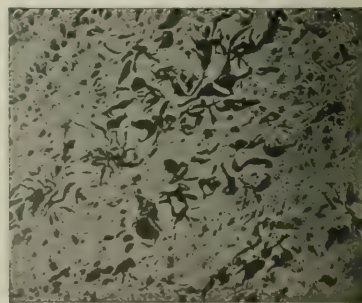


FIG. 24—UNETCHED

(MAGNIFIED 100 DIAMETERS.) POOR IRON. SILICON, 0.72; OXYGEN, 0.009 PER CENT. BREAKING STRENGTH, 1.25-IN. BAR, 2500 POUNDS, 2500 POUNDS

much more active element chemically than iron in all particulars. As a result, it takes the sulphur away from the iron and forms with it manganese sulphide. It is a general law of metallurgy that a metal will dissolve compounds of itself, but not compounds of another metal with anything like the same facility. In consequence of this law, the manganese sulphide separates out from the iron and rises to the surface. It may be seen doing this in the ladle under certain conditions, and even where it does not separate out completely, manganese sulphide, not being dissolved by iron, is much less harmful than iron sulphide, which is dissolved by it with the consequences above described.

The first effect of the addition of manganese is,

therefore, to remove a part of the sulphur. The action is not quantitative, and several times the amount of manganese sufficient to form manganese sulphide with all the sulphur present must be added to obtain the removal of much of this latter. The manganese which does not combine with the sulphur combines with the iron, when molten, in the condition of a double carbide.

Manganese, having a higher affinity for carbon than iron, causes an increased absorption of carbon by the metal in the blast furnace, even up to 6 or 7 per cent in ferro-manganese and up to 4 or 5 per cent, in spiegeleisen containing from 18 to 22 per cent of manganese.

The effect of the manganese itself, after it passes 1 or 2 per cent, is to harden the iron, by holding more of the carbon in the combined condition. This increases

knife-like crystals with extremely smooth faces, so that the end of a broken pig of spiegel often shows crystals sticking out almost like knife blades, and the whole surface is made up of the faces of intersecting crystals with but little cohesion with one another.

It is probably this tendency which gives car wheels, which obtain their chill by the use of manganese, their tendency to "shell out," that is to say, under extra stress, a group of these crystals lose their cohesion with one another, loosen and finally fall out, producing what car-wheel men call a "shell-out." Moreover, the manganese chill is much softer than a straight iron chill, and breaks down under wear.

The activity of manganese as a deoxidizer, as well as a desulphurizer, is well known, and when manganese is added to metal high in oxygen some of this latter oxygen

is promptly scoured out; the chilling power and strength of the metal are thereby reduced. On the other hand, if still more manganese be added, when $1\frac{1}{2}$ to 2 per cent is reached, the strength of the iron and its chilling power increase, on account of the direct action of the manganese in throwing the carbon into the combined condition, but in the form of flat plates, as I have just explained.

This conflicting tendency, in conjunction with its effect in removing sulphur and the powerful effect of that element on the quality of the castings, makes it perfectly evident that the rôle of manganese is an extremely complicated one, but, on account of this powerful deoxidizing influence, it is my judgment that it should be kept low in all castings where the highest qualities, particularly strength, closeness of grain, and chilling power, are desired, because while these qualities of a kind can be obtained by the use of manganese in considerable quantity, the fundamental structure of the iron produced is inherently inferior to the structure produced by the presence of oxygen, and it is a matter of established practice that, in the production of chilled castings, the desired result cannot be obtained by the addition of ferro-manganese alone, as at one time was thought to be the case.

Some manganese, perhaps up to 0.5 or 0.6 per cent, is desirable in cupola melted iron, to hold the sulphur in check, and it may be useful for other purposes in special cases, but for the best castings manganese should generally be kept within very moderate limits. Some of the manufacturers of chilled rolls will not tolerate it above 0.30 per cent.

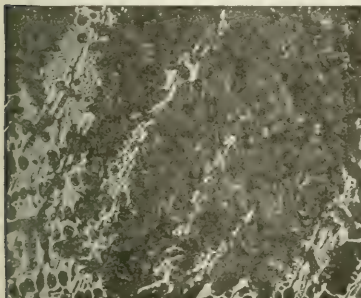


FIG. 25—ETCHED

(MAGNIFIED 100 DIAMETERS.) REMELT. SILICON, 0.70 PER CENT. BREAKING STRENGTH, 1.25-IN. BAR, 4150 POUNDS

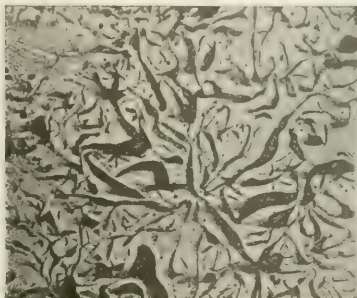


FIG. 26—UNETCHED



FIG. 27—ETCHED

(MAGNIFIED 100 DIAMETERS.) REMELT. SILICON, 0.72 PER CENT. BREAKING STRENGTH, 1.25-IN. BAR, 2750 POUNDS

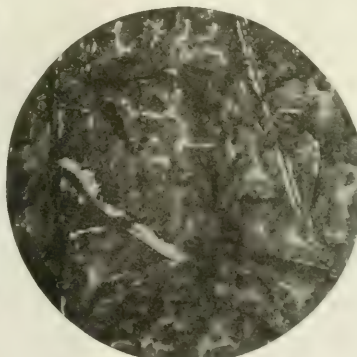


FIG. 28—ETCHED

(MAGNIFIED 70 DIAMETERS.) COKE IRON. NOTE THE LONG, SLENDER BODIES OF GRAPHITE AND FERRITE SIDE BY SIDE FORMED BY THE BREAKING DOWN OF CEMENTITE CRYSTALS

the strength of the matrix in ordinary gray irons and also limits the formation of graphite. The result of these actions is that manganese strengthens the iron in addition to increasing its chilling power, and it is used for this latter purpose to make chilling irons harder, as well as to make soft irons softer.

It is obvious, from what has been said, that these actions are the results of two different sets of effects, one of which predominates in the one portion of the manganese range and the other in the other. The objection to the use of manganese for producing chill is that iron containing much of it crystallizes into large,



FIG. 29—UNETCHED. (MAGNIFIED 100 DIAMETERS.)
"SPECIAL" CHARCOAL IRON, SHOWING FINELY DIVIDED AND ALMOST COMPLETELY NODULAR GRAPHITE

The Effects of Time

Before discussing the effect of other elements on the iron-carbon alloys, it might be well to discuss the effects of time. The iron-carbon diagram shows only equilibrium conditions, and the time required for the attainment of some of the equilibria shown by the iron-carbon diagram is extremely short, while for others it is very long. Hence the diagram cannot tell us what will happen in any case unless the time factor is considered.



FIG. 30—ETCHED. (MAGNIFIED 100 DIAMETERS.) SAME AS FIG. 29

The most important effect of time (that is, of the rate of cooling) is its influence on the graphitization of the carbon after solidification. The evolution of graphite during cooling through the molten condition seems to occur only with hypereutectic irons, and this appears to be a function of time, because irons which throw off graphite into the air as they run from the furnace can only be converted into good castings from this initial heat by pouring hot and just as quickly as possible. If poured slowly, the graphite will accumulate at the top of the mold so as to make the whole top of the casting worthless—it will be "worm eaten" at the best, and at the worst may contain great cavities filled with loose graphite flakes of large size. Whether hot pouring simply causes the metal to set more quickly and thus prevent the rising of the hypereutectic graphite, or whether the formation of the graphite is actually prevented, I have never determined, but it is probable that both effects play a part.

In regard to the graphitization after solidification, our knowledge is more definite. In this case all the carbon not thrown out as hypereutectic graphite is combined at solidification, and, if the cooling be rapid from that point, the iron will remain perfectly white. But, if the casting be made to cool slowly, it will not only graphitize, but the graphite may form into very large flakes. The best illustration of this is to be found in the salamander taken from the hearth of the furnace after blowing out. This contains huge flakes of graphite an inch or two in extent, and the intersections of the flakes cut the iron into irregular solids quite without cohesion, so that a large lump of salamander can frequently be broken apart with the fingers into pieces of small size, each consisting solely of iron and graphite. Fig. 34 shows a microphotograph of such a piece, and shows why this must be so. The iron in this case has remained just below the melting-point for several years.

From this point of view, the action of chilling becomes extremely simple. We merely shorten the time

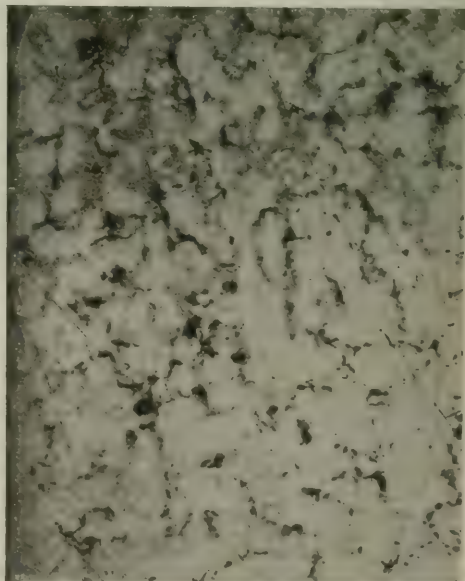


FIG. 31—UNETCHED. (MAGNIFIED 100 DIAMETERS.) COKE IRON-OXYGEN. SAME AS FIG. 6. (KINDNESS OF PROFESSOR CAMPBELL)

of cooling through the range in which graphitization could take place so as to prevent or diminish this action and leave the carbon in the combined condition. The surface next the "chiller" is the whitest and hardest, because its heat is removed instantly, while the metal back of it has to be conducted through the chilled surface and also through the warmed face of the chiller into the cold metal behind it. This is obviously a much slower operation, and, as a result, more graphitization can occur in the metal behind the chilling face.

In the same way, if the chiller be too light in proportion to the body of the metal to be chilled, a very insufficient chill will result, because the thermal capacity of the chiller is only sufficient to absorb the heat from a thin zone of the molten metal, and this is promptly heated up again by the larger body of molten metal behind, which "draws" the chill already formed, exactly as a blacksmith draws the temper of the quenched edge of a tool.

Silicon and time, then, are seen to be the principal factors making for graphitization, while oxygen, sulphur, and manganese are the principal ones resisting it. Of these three, manganese is hostile to the other two, and, if present in sufficient quantity, destroys their effect, while its own effect does not alone give a chill

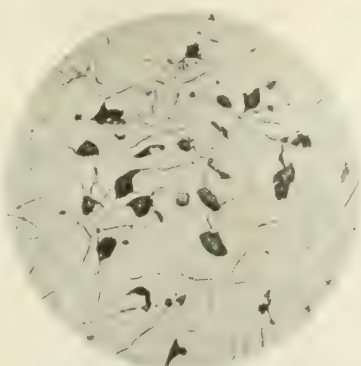


FIG. 32—UNETCHED. (MAGNIFIED 100 DIAMETERS.) OXYGENATED COKE IRON, SHOWING NODULAR CONDITION OF GRAPHITE

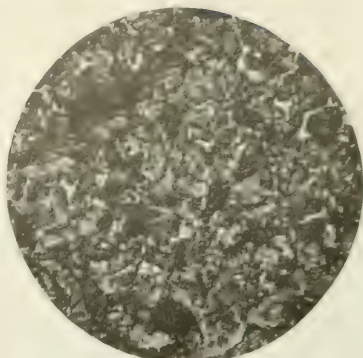


FIG. 33—ETCHED. (MAGNIFIED 100 DIAMETERS.) SAME AS FIG. 30

of the character desired. Sulphur gives a hard chill, but an essentially brittle and unreliable one, accompanied by high shrinkage and weak structure back of the chill. Oxygen gives a tough, hard chill, low shrinkage, and the strongest and best structure back of the chill.

(To be Concluded)

The Hydraulic Press Manufacturing Co., Mount Gilead, Ohio, has received an order for 70 hydraulic hot plate presses to be used for vulcanizing purposes. They will be operated from hydraulic pump and accumulator systems already installed and are all of one design with a pressure capacity of 115 tons each.

Some Uses of Magnesite.—Magnesite is used for the manufacture of epsom salts, carbon dioxide for mineral waters, etc., patent floorings for buildings, cupels for assaying, cement for lining tube mills used on the Rand, South Africa, basic fire-bricks, body for certain paints and mixed with asbestos for making roofing materials, tiles, etc. (South African Mining Journal, Sept. 9, 1916, p. 31.)

British Zinc Smelting Industry. The British Government has agreed to purchase 100,000 tons of zinc concentrates per annum for the period of the war and ten years thereafter from Australia. This contract will assure Australia of a steady outlet for ore and at the same time opens up a much needed source for Great Britain. The British Government has also agreed to lend the Australian Commonwealth \$2,500,000 for the erection of smelting plants and to take yearly 45,000 tons of the spelter produced. In the past Great Britain consumed approximately 195,000 tons of spelter per annum. With the 100,000 of zinc concentrates, which furnish in the neighborhood of 30,000 tons of spelter and the 45,000 tons of spelter furnished in the near future by Australian smelters, England will produce, with its own 60,000 tons, about 135,000 tons of spelter. It is seen, therefore, that approximately 60,000 tons of spelter will still have to be sought elsewhere to furnish the required tonnage of spelter for Great Britain.

Zinc in Japan. In a short time the new zinc plant built at Hikoshima, in the Shimoneski Straits, by the Suzuki Shoten of Kobe will be completed. Operations were commenced in April, 1916, and when the plant is completed it will employ about 4,000 people.



FIG. 34—ETCHED. (MAGNIFIED 100 DIAMETERS.) SALAMANDER. THE HEAVY BANDS OF GRAPHITE HAVE COMPLETELY DESTROYED THE CONTINUITY OF THE STRUCTURE

Synopsis of Recent Metallurgical and Chemical Literature

Conversion Tables

Conversion Tables for the Valuation of Ores, Minerals and Metals is the title of an article in the September, 1916, number of *The Mining Magazine*, pp. 152 to 155. It is one of the unfortunate conditions faced by those concerned with the international trade in metals, that the standards of weights and measures, as well as the monetary systems in various countries, are not the same. Anything, therefore, which will facilitate the calculations involved in the market manipulations of metals, etc., is of paramount interest to the metallurgical industries. The first table illustrates the effect on exchange, when the market prices per pound in cents change and have to be converted to pounds sterling per ton for the English market. Table II is a conversion table for converting cents or pence per pound into pounds sterling per ton, and Table III converts values in pence or cents per unit, or vice versa, to price in pounds sterling per ton, at various percentages. For the tables the reader is referred to the original article.

Flotation

Pine Oil for Flotation Purposes.—An article published in the October, 1916, *Bulletin* of the Canadian Mining Institute treats of experiments conducted by T. R. JONES at the Buffalo Mine, Cobalt, Canada, to determine the feasibility of producing a pine oil suitable for flotation from Canadian pine trees. The materials tried were spruce wood, spruce bark, jackpine stumps, white cedar needles, and Norway pine stumps. These materials were subjected to dry distillation and the products investigated. The conclusions drawn from the tests were: Norway pine stumps were best suited for producing oils; the distillation need not be carried above 400 deg. C., as further heating produces heavy tar; the use of superheated steam aided in the starting of the distillation, but did not prevent the cracking of the oils, and finally in redistilling the oils the pressure maintained on the vapor has a marked effect on the final products; a sufficiently low pressure breaking up all the pitchy products into a sort of paraffine.

Gold and Silver

Mining and Milling Practice at Santa Gertrudis.—A paper under this title was published in the August *Bulletin* of the American Institute of Mining Engineers, pp. 1295 to 1332, written by HUGH ROSE. Fig. 1 gives a complete flow sheet of the mill, the details of which are clearly indicated. The main feature of construction is the sacrifice of compactness in order to obtain a gravity flow, the slope of the mill site being 17 deg. The capacity of the plant is 1100 tons per day, and the milling business is conducted on a custom basis. The total cost of the plant was \$792 per ton daily capacity.

A great deal of experimental work has been conducted on aluminium dust precipitation, electrolytic regeneration of cyanide, electrolytic refining of precipitates and flotation concentration. It was found that aluminium dust precipitates yield a bullion 975 fine, and that the aluminium dust required was about one-third that of the zinc dust. The slight increased cost per ton of ore of aluminium dust is more than offset by the decreased consumption of cyanide, the net saving being \$0.15 per ton of ore.

In the electrolytic regeneration of the cyanide the main difficulty was to find an anode of high conductivity that would not dissolve or disintegrate. The anode finally decided on was one composed of lead containing 6 to 9 per cent of antimony. The conclusions drawn

from the work were: The solution to be treated electrolytically must be barren of gold and silver to avoid precipitation; the regeneration of the cyanide takes place at the cathode, with a decomposition at the anode. The latter may be overcome by maintaining a high protective alkalinity at the anode; to maintain an alkaline anolyte a porous partition such as canvas is used, the circulation of the anolyte and the catholyte being accomplished individually; the voltage drop per cell, at a current density of 15 amperes per sq. ft. of anode surface, treating barren solution containing 0.5 per cent total KCN and 0.115 per cent CaO, with canvas diaphragm and electrodes 1½ in. apart, is 6 volts at 70 deg. Fahr. Under these conditions the solution flow should be at least 0.25 gal. per sq. ft. of anode surface; the cathode deposit analyzed 71 per cent zinc, with copper, iron, arsenic and organic matter as impurities; the reaction taking place is $\text{NaZn(CN)} + \text{Ca(OH)}_2 + \text{current} = 2\text{NaCN} + \text{Ca(CN)}_2 + \text{Zn} + \text{H}_2\text{O} + \text{O}$; the reduction of the cost was \$0.12 per ton of ore. The equipment cost more than for aluminium dust precipitation.

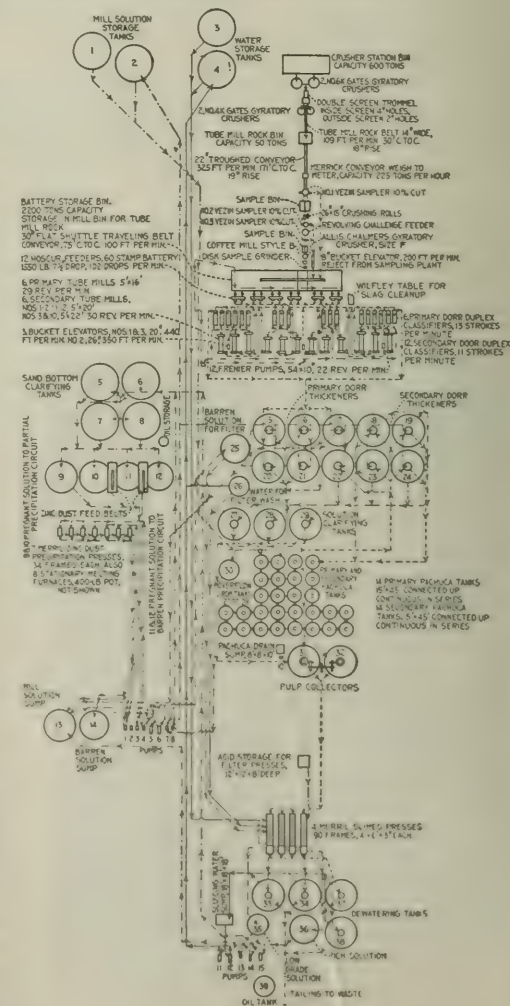


FIG. 1—MILL FLOW SHEET

The electrolytic refining of the precipitates was only in the preliminary state, and no conclusions are given. The main difficulties to be overcome are resistance of the precipitate to the current purification of the electrolyte, high acid consumption due to impurities and refining and melting of the gold slime.

The preliminary experiments on flotation gave the following results: One-third pine oil or wood creosote and two-thirds Mexican gas oil are the most satisfactory oils as far as the oil tests have been made; no particular benefit is derived from the addition of acid; a slight alkalinity not exceeding 0.03 lb. lime per ton solution is satisfactory; heating the solution shows no material improvement; the flotation tailings are readily cyanided; the raw flotation concentrate cyanides as readily as gravity concentrate; with laboratory machines a recovery of 65 to 70 per cent can be made by flotation, the ratio of concentration being between 80 and 90 to 1. A 100-ton testing plant is being constructed, and good results are anticipated.

Copper, Lead and Zinc

Comparison of Electrolytic and Lake Copper.—C. H. MATHEWSON and E. M. THALHEIMER cover this topic in an article published in the July *Bulletin* of the American Institute of Mining Engineers. Samples of electrolytic copper and two typical samples of lake copper were tested with respect to strength and ductility, both when cold worked and after annealing.

The two samples of lake copper were one known as Mohawk and carrying 0.096 per cent arsenic, and the other known as Copper Range Copper, and carrying 0.296 arsenic. Tables and curves are given summarizing the work. The conclusions drawn are: During the early stages of rolling, Copper Range Copper decreases more rapidly in ductility than electrolytic copper, but both products increase in strength about equally. During the later stages of rolling both products decrease about equally in ductility, but the Copper Range Copper increases more rapidly in strength than does the electrolytic copper. The Mohawk brand lies between the two others. The differences in ductility, as measured by reduction of area, are confined to the earlier stages of rolling.

Generally speaking, the Copper Range product takes a harder temper on rolling than the electrolytic copper, but does not finally become less ductile. They both seem to stand the same amount of rolling, but the electrolytic copper rolls slightly easier.

If it is desired to finish a previously annealed product with a limited amount of ductility, but increased strength, by rolling through several gages, Copper Range metal is preferable, as the strength is increased considerably without sacrificing the ductility.

The results obtained from the tests after annealing under oxidizing conditions show that the differences in strength throughout the range of 400 deg. C. to 1000 deg. C. were slight. The Copper Range metal always showed the highest reduction of area and elongation, then followed the Mohawk, and lastly the electrolytic copper. Near the temperature of deterioration, beginning at about 700 deg. C., the relative ductilities of the Copper Range and the electrolytic copper are such that the former can stand an additional 100 deg. of over-heating before dropping to the ductility value of the latter.

Tests after annealing under reducing conditions show that in general Copper Range material is slightly less susceptible to the evil effects of reducing annealing than either of the other two varieties. None of these coppers will retain its ductility after annealing above 40 minutes in a strong reducing atmosphere at 600 deg. C.

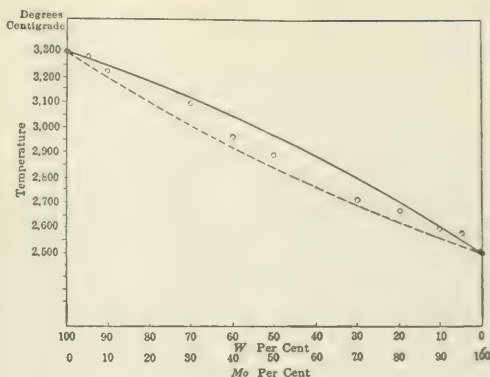


FIG. 2.—EQUILIBRIUM DIAGRAM OF TUNGSTEN AND MOLYBDENUM

A large number of microscopic photographs with the necessary explanation terminates this article.

Tungsten and Molybdenum

The Tungsten-Molybdenum Equilibrium Diagram.—ZAY JEFFRIES, in the July *Bulletin* of the American Institute of Mining Engineers, treats the above-mentioned subject and also the system of crystallization of tungsten and molybdenum. The melting points were determined by the fusion wattage method. The apparatus and procedure used are fully described with a discussion on the accuracy involved. The diagram obtained by Jeffries is reproduced in Fig. 2, and shows that the alloys form an unbroken series of solid solutions. Microscopical determinations prove undoubtedly that both molybdenum and tungsten crystallize in the isometric system. The article contains several interesting microphotographs.

Allotropy

Allotropy of Silver.—In a paper presented at the recent London meeting of the Institute of Metals, Dr. W. D. HELDERMAN of Utrecht University, Holland, gave the results of investigations on the allotropy of silver. The author was awarded a Carnegie research fellowship to carry on investigations on the metastability of metals, and had originally intended to experiment with iron. As silver could be obtained in a very pure state and the problem was not so complicated it was decided to substitute this for the iron.

The author reviewed the work of others and then described his own work consisting of very accurate determinations of the density of pure silver after heat-treating in various ways. The results indicated the existence of at least three varieties of silver, but it was not possible to obtain the forms each in a state of purity.

The conclusions finally arrived at were as follows:

- (1) Silver has a transition point at about 77 deg. C.
- (2) Pure silver consists of at least three allotropic forms.
- (3) All objects made of silver are in a metastable condition as a result of the retardation in the transition of the altered form.
- (4) All physical constants of silver (except the atomic weight) refer to indefinite mixtures of the different allotropic forms. New experiments are wanted to obtain constants for the different forms of silver in a pure state.

The discussion following this paper as given in *Engineering* (London) is quite interesting.

The discussion was opened by Dr. Rosenhain, who

said he found a difficulty in treating the paper seriously. He had read a lot of the papers sent out from Utrecht on alleged cases of allotropy, but so far had failed to see how it was possible to base on the experiments there made the sweeping conclusions put forward. The whole evidence was provided by measurements on density and volume. Even supposing these changes were great, would it be necessary to attribute them to allotropy? Certainly, in the cases discussed by Dr. Helderman, there was no such necessity whatever. In the first place the material used consisted of turnings, so that the metal examined had been severely cold-worked. Consequently if Beilby's view was true—and it was generally accepted—we had in the amorphous phase produced by the cold working a complete explanation of the author's observations. The temperature at which the amorphous phase began to go back was quite low, and for such changes as were noted in the paper might well occur at ordinary room temperatures. In short, before any serious attentions could be paid to claims for allotropy based on density measurements, the experiments must be made with massive silver annealed at a high temperature so as to get rid of the amorphous phase. As for the changes observed at 25 deg. C., he thought the author's suggestion the least probable of any. As a matter of fact metals were not impervious to water. Thus, at the National Physical Laboratory, Mr. Sears had found that solid hammered and polished metal which it had been intended to use for standard weights would absorb an appreciable quantity of water, about one part in a million. The alloy in question consisted of equal parts of copper and nickel, but in spite of its solidity and smooth and relatively small surface, it took up by absorption or adsorption an appreciable amount of water, some of which was expelled at high temperatures. Such an absorption would readily account for all the author's results. Again, when the author found no appreciable emf. between his supposedly different varieties of silver, he did not reach the obvious conclusion that there was no allotropy, but assumed that one of his modifications persisted in both. Again, the author's contention that the expulsion of gas from a metal must necessarily increase the density was untenable, since, if the metal occupied the same volume as before, the weight would be diminished by the gas lost and a lesser apparent density would naturally result. Indeed the author's final remark completely disposed of his own paper. He stated that all the physical properties of silver so far measured referred merely to indefinite mixtures of three allotropic modifications, and would therefore all have to be redetermined. As a matter of fact, about the most accurate and consistent determination yet made of any physical constant was the electrolytic equivalent of silver. This had been measured in London, in Berlin, and in America, and the results were most consistent; and yet they were told that in such work they were dealing with indefinite mixtures.

Professor Turner said that he understood that Dr. Rosenhain did not question the accuracy of the author's measurements, but merely the conclusions arrived at. He himself had found no evidence in the paper of the three allotropic varieties postulated by the author. What were they? Did one exist above 77 deg. C., another at 77 deg., and a third below this temperature? It was obvious from the paper that there was no great volume change, and the calorimeter showed no important thermal change such as would lead to a belief in an allotropic variation. The turnings used by the author had been greatly stretched in the process of production, and rendered lighter, so that the increase of weight found on annealing should be attributed to the fact that the metal had been cold worked, rendering it amorphous.

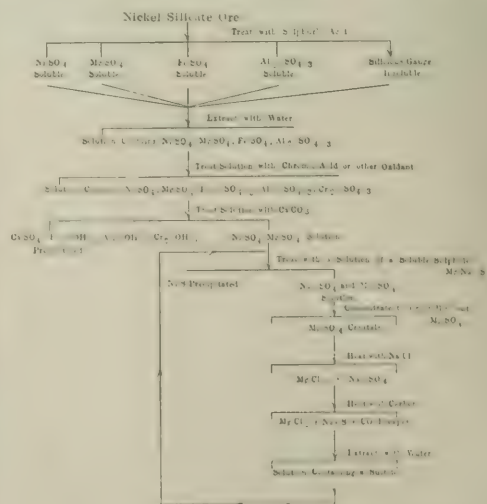
Whether this was an allotropic change was a matter of definition, but any surface rendered smooth by buffing was rendered lighter than the mass of metal below. Dr. Rosenhain suggested that the silver had absorbed water in the author's tests. It should be noted, however, that the metal was immersed the whole time, and after a certain interval the effect of the liquid might not be very great.

Mr. Smith, who followed, said that Dr. Burgess of the Washington Bureau of Standards, had observed that there was a complete analogy between the diseases of metals and of men, the closeness of which was enhanced by the fact that in both cases some of the diseases were imaginary, being due, in the case of metals, to what Dr. Rosenhain had called "allotropy gone mad." The speaker found nothing in the author's paper which could not be explained by Stas's assumption of an absorption of gas by the metal. Silver, if heated in vacuo lost, in fact, a considerable weight of gases, and this loss was not immediate but extended over a considerable time. As an extreme case, showing the necessity of caution in interpreting changes of density, spongy gold might be taken. Water-logged spongy gold had the same density as pure rolled gold. If dried and partially annealed the density fell to about 13, and if then left in water it rose to 14 or 15, but it never recurred to the original figure. To get it back to 19 it was necessary to re-melt it, and hammer it out. He suggested, accordingly, that in the author's experiments the silver was water-logged up to 80 deg. C., at which temperature the imprisoned air on the pores to which the water had not excess, expanded. In his view the ultimate test of allotropy was whether there were changes in other properties of the metal.

Recent Chemical and Metallurgical Patents

Nickel and Cobalt

Process of Extraction of Nickel.—A patent has been granted to HENRY LIVINGSTONE SULMAN and HUGH FITZALIS KIRKPATRICK PICARD of London, England, for the extraction of nickel from its ores and particularly from garnierite ores. Fig. 1 is a flow-sheet of the various steps of the process, the main features being treating of the ore with sulphuric acid, converting the



metallic constituents into the sulphates and eliminating the silica from the gangue, by washing with water. The sulphate solution is then oxidized with a strong agent, such as chromic acid and treated with calcium carbonate. This precipitates the iron, aluminium and chromium as hydroxides and leaves magnesium and nickel in solution as sulphates. The nickel is precipitated by the addition of a soluble sulphide such as sodium sulphide. The sulphide is regenerated by concentrating the solution left until the magnesium sulphate has crystallized out. The mixed mass of magnesium and sodium sulphate crystals is then calcined with sodium chloride and carbon and when cool extracted with water, giving the soluble sulphide which is reused in the process. (1,193,734, Aug. 8, 1916.)

Electrolytic Extraction of Cobalt Oxides.—A patent was granted to KENNETH S. GUTERMAN of New York, N. Y., for a method of obtaining oxide of cobalt by the electrolysis of solutions containing a cobalt salt. The essentials of the process are, that the electrolyte pass downward in respect to the electrodes, which hang vertically in the electrolytic trough; that a soluble chloride be present in the electrolyte which forms chlorine on electrolysis, which will form hypochlorite in the solution and as such act on the cobalt salt in the electrolyte; finally some agent must be added capable of preventing the formation of free acid, as this would redissolve the oxide. The neutralizing agent used by the patentee was sodium carbonate, added after the electrolyte has passed the anodes, so as to prevent the precipitation of a cobalt compound from the fresh solution. The efficiency of the process depends on the maximum amount of hypochlorite being formed and on the careful neutralization at the free acid formed during the process of electrolysis. (1,195,211, Aug. 22, 1916.)

Iron and Steel

Reducing Flue Dust.—A patent has been granted to SAMUEL L. BOGGS of Pittsburgh, Pa., for a process for reducing flue-dust and other metallic fines. The underlying principle of the process is the emptying of the flue-dust or metallic fines into molten metal, mixing and then applying a blast of gas generated in the furnace to the surface of the said mixture. The mixing of the molten metal and the dust may be conducted in any possible manner, with or without fuel and with or without extra flux. Apparatus and the mode of operation are fully described in the patent. (1,190,712, July 11, 1916.)

Copper, Lead and Zinc

Copper Coatings on Iron.—Sherard Osborn Cowper-Coles of Westminster, London, England, has patented a process for obtaining adhesive coatings of copper upon iron or steel. The process consists in first cleansing the iron or steel surface, and then rendering it passive by subjecting it to the action of concentrated nitric acid, chromic acid, or potassium hydroxid or by making it the anode in a suitable electrolyte or any other well-known method. The metal thus treated is then immediately removed to an electrolytic copper depositing tank where the copper is deposited on the passive surface in an adhesive form. The copper depositing tank should have the anode and the cathode in the electric circuit prior to the introduction of the passive metal so that the latter may be immediately covered with copper on its immersion. (1,198,703, Sept. 19, 1916.)

Brass and Copper Alloys.—A process for making brass and copper alloys has been patented by GUILLAM H. CLAMER of Philadelphia, Pa. Melted copper of the correct "pitch" is drawn off into an electric furnace.

Zinc and other alloying metals are then added in the electric furnace. The economy obtained in this process lies in the fact that large amounts of copper are melted and brought to the proper "pitch" before entering the electric furnace, that alloying is done in the electric furnace and the casting at the proper temperature. The alloying and casting can be readily accomplished in the electric furnace due to the easy regulation of the atmosphere to neutral or reducing, and to the ease with which the temperature can be controlled. Due to the regulation of the furnace atmosphere little or no zinc is lost by volatilization if zinc is used in the process of alloying. Large slabs may be cast which again is a material saving as it costs little, if anything more to handle a large slab than it does to handle a small one. (1,198,618, Sept. 19, 1916.)

Roasting Furnace for Lead Matte.—A patent for treating lead matte has been granted to UTLEY WEDGE of Ardmore, Pa. The object of the patent is to roast lead matte or similar material in a shelf furnace, and provide means for the driving off of the sulphur without causing the fusing or sintering of the matte or

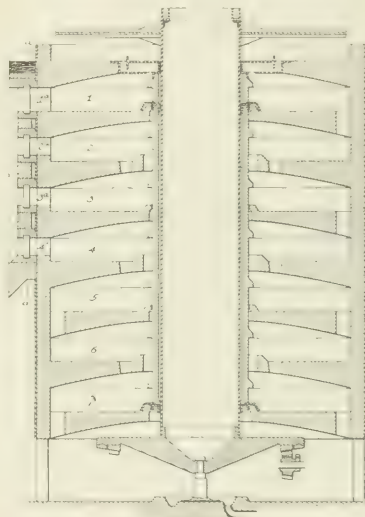


FIG. 2—VERTICAL SECTION OF LEAD MATTE ROASTING FURNACE

rendering it sticky so as to interfere with the mechanical operation of the furnace. While it has been possible to roast matte in a single-hearth furnace, the cost of fuel has been rather high, and it has been thought desirable to roast lead matte in a multiple hearth furnace if the above-mentioned improvements could be made. Wedge found, after extensive experimental work, that matte containing a considerable amount of sulphur (approximately 20 per cent) became sticky at 1400° F, but that as the roasting progressed and the sulphur contents of the matte decreased, the temperature to which the matte could be subjected without becoming sticky rose steadily, until, with a sulphur content of 13 per cent, the calcines could be subjected to a temperature several hundred degrees above 1400° F without sticking.

The principle carried out in the invention is therefore to maintain a lower temperature in the upper part of the furnace than in the lower portion. This is accomplished preferably by abstracting heat from

the gases rising from the lower to the upper chambers of the furnace. The matte passes in a counter direction to the gases. Sulphur is thus eliminated without sintering or making the matte sticky.

Fig. 2 is a vertical section and Fig. 3 a transverse section along the line *a-a* of the furnace. The furnace has seven treating chambers, the chambers 1, 2, 3 and

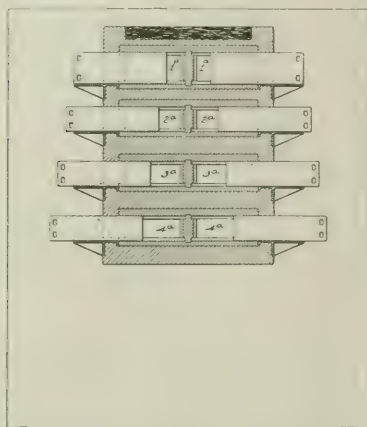


FIG. 3—TRANSVERSE SECTION OF WEDGE LEAD-MATTE ROASTING FURNACE

4 being provided with dampered outlets 1a, 2a, 3a and 4a, from which the escape of the heated gases is regulated. The control of the temperature in the upper part of the furnace may be accomplished by various means. The method employed in the furnace described is to have internal air ducts in the hearths 1, 2, 3 and 4. By means of these ducts the temperature of the hearths may be increased or lowered by decreasing or increasing the supply of air to the ducts. Another method of accomplishing the same end is to have rabble arms of such dimensions as to permit of the absorption of surplus heat by cooling fluid circulated within the rabble arms. The temperature in this case will be governed by the lesser or greater amount of fluid circulating in the arms. (1,198,882, Sept. 19, 1916.)

Recovering Copper from Solutions.—GEORGE A. SCHROTER, of Denver, Colo., and WILLIAM C. LAUGHLIN, of Nogales, Ariz., have patented a process of recovering copper from solution. Calcium hydroxide in solution is added to the solution containing the copper, followed by filtering same, roasting or calcining the precipitate so as to render the iron inert, adding sulphuric acid to the precipitate and filtering off the copper solution. (1,200,534, Oct. 10, 1916.)

Wet Copper Process.—A patent of JOHN C. GREENWAY, of Warren, Ariz., refers especially to the extraction of copper from its ores. The basic principle is that when copper-bearing solutions containing ferric sulphate are rendered neutral by repeated circulation of the solution on the ore, and are thus subjected to an excess of natural oxidized copper compounds, the detrimental ferric sulphate will be precipitated from the solution in an insoluble or partly insoluble oxide. This is then removed from the system with the mechanical moving of the tails. The chemical equation involved is: $3\text{CuO} + \text{Fe}_2(\text{SO}_4)_3 = 3\text{CuSO}_4 + \text{Fe}_2\text{O}_3$.

Fig. 4 represents one form of apparatus, which may be employed. A, B, C, D, E, F, G and H repre-

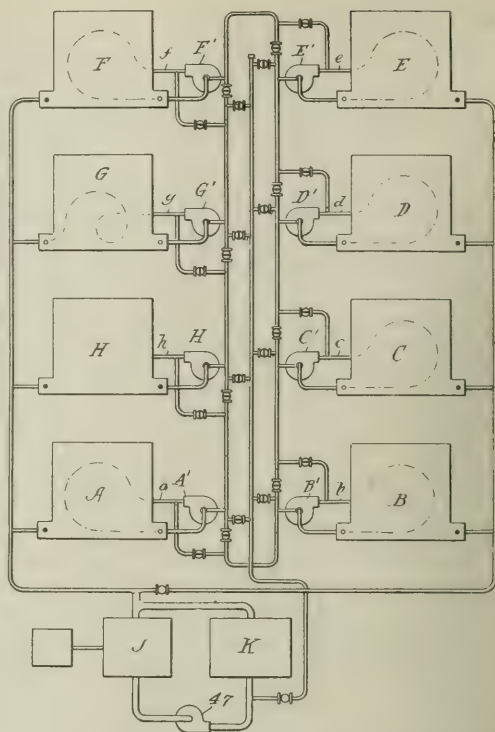
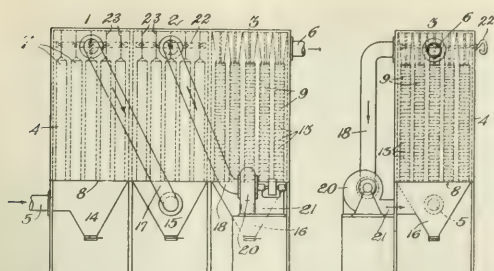


FIG. 4—APPARATUS FOR EXTRACTING METALS FROM THEIR ORES

sent a series of tanks containing the ore to be leached. In the bottom of these tanks is a perforated false bottom, which acts as a filter for the leaching solution. Tank K is the electrolytic cell, J is the sump tank and M is the tank containing the sulphuric acid used in the process of leaching. A', B', C', D', E', F', G', H' and 47 are pumps used to circulate the various solutions through the pipe system, as indicated in the drawing. The patent gives a detailed description of the apparatus and its use. (1,200,832, Oct. 10, 1916.)

Chemical Engineering

Purifying Gas in Sulphuric Acid Manufacture.—A patent granted to CARLTON F. MOORE, of Salt Lake City, Utah, applies to the purification of the dust-laden gases obtained from furnace operations, which are to be employed in the manufacture of sulphuric acid. In making sulphuric acid by the contact method it is of paramount importance that the gases be freed from all the dust or solid matter before coming in contact with the platinum catalyzer, as any dust will make the catalyzer inactive. It is the object of this patent to provide a method for continuously and economically removing, by filtration, said solid matter. The basic principle underlying this process is to remove the accumulated dust from the bags preceding the final bags of the series only. The final bag, from which the gases pass to the catalyzer, is not disturbed or cleaned, while the preceding bags may be cleaned at will to permit the successful passage of the gases. At each cleaning of the first series of fabrics a comparatively small quantity of solid material will pass through the fabric and collect on the second bag of



FIGS. 5 AND 6—SECTIONS OF APPARATUS FOR PURIFYING GASES

the series. This accumulation is, however, very slow and the second fabric will require little cleaning, while the third fabric, which preferably should be the final one before entering the catalyzing chamber, needs no cleaning. To assure a complete cleaning of the gases before entering the catalyzer, the final bag, especially when new, has its interstices filled with dust before any gas is passed.

Figs. 5 and 6 show a side elevation and an elevation of a device which will answer for the purpose, while Fig. 7 indicates means for supporting the final bag or fabric in a fixed position. The apparatus comprises a bag chamber 4, divided into three sections, 1, 2 and 3. 5 and 6 are the in- and outlet for the gases respectively. Sections 1 and 2 have bags as ordinarily used, while section 3 contains the fixed bags. These latter bags, indicated by 9, are supported in a fixed position by cylinders 10, made of wire cloth, which surround the lower thimble 11 and the upper closed thimble 12. The bags are retained in position on the wire cylinders

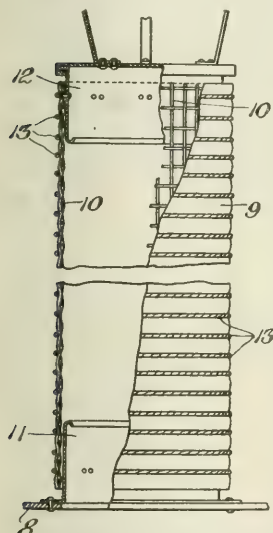


FIG. 7—SECTIONS OF APPARATUS FOR PURIFYING GASES

by cords 13. The gases are supplied to the respective sections by means of closed hoppers 14, 15 and 16. Pipe 17 connects section 1 with hopper 15, and pipe 18 connects section 2 with a fan 20, which itself is connected with hopper 16 by means of pipe 21. (1,184,006, May 23, 1916.)

Gold, Silver and Platinum Group

Separation of Precious Metals.—A patent has been granted to ALBERT H. SHERWOOD, of Oroville, Cal., for a process of separating metals. The invention relates especially to treating pulp, black sands, concentrates and other materials for the separation therefrom and the recovery of the precious metals—gold, platinum, palladium, osmium, iridium, ruthenium and rhodium. The material is finely or coarsely ground, as circumstances may demand, and placed in a suitable receptacle.

Enough 15 per cent to 25 per cent sulphuric acid is added to saturate and cover the pulp, followed by stirring until thoroughly mixed. Then it is allowed to stand from thirty to forty minutes. This treatment causes the pulp to become puffy and light, and the values are cleansed from oxides, grease, etc. The acid thus used has not exhausted its strength and is reused.

In a second receptacle, consisting of a clean iron pan, an amalgam bath is made, consisting of $\frac{1}{2}$ lb. of 25 per cent copper sulphate solution, 1 lb. of copper sulphate crystals, and 5 to 7 oz. of mercury. A few drops of sulphuric acid are added and the mass is thoroughly ground. The mercury combines with the copper solution forming an amalgam, which adheres to the side of the pan. The contents of the first receptacle are added to the second and subjected to agitation for about one hour. The copper solution then penetrates the pulp and coats the native metals, while the sulphuric acid maintains the pulp and minerals in a suitable condition for rapid amalgamation. After the prescribed agitation, water is admitted slowly, agitation being maintained constantly, and the native metals are washed and amalgamated with the copper amalgam.

The amalgam is washed and removed to a third receptacle and treated with 50 per cent nitric acid. Mercury, silver, copper and lead go in solution, while the gold, platinum, iridium, etc., remain undissolved. The solution is removed and a solution of cobalt nitrate is added in its place. The strength of the cobalt nitrate solution is 12 per cent. This is allowed to stand in contact with the residue for five to ten minutes and then pure mercury is added. The amount of mercury required is from $\frac{1}{2}$ to 1 oz. The function of the mercury is to amalgamate the gold. The gold amalgam is then removed to a fourth receptacle. The residue left in the third vessel is treated with 50 per cent nitric acid. This acid removes any mercury and cobalt. This solution is removed and the residue containing platinum, palladium, iridium, osmium, etc., is thoroughly washed. The effect of the cobalt nitrate solution with the mercury is to liberate the gold from the metals of the platinum group. (1,192,945, Aug. 1, 1916.)

Electrolytic Processes

Sodium Amids.—A process for the manufacture of alkali-metal compounds has been patented by EDGAR A. ASHCROFT, of London, England, particularly the production of sodium or potassium amids from sodium or po-

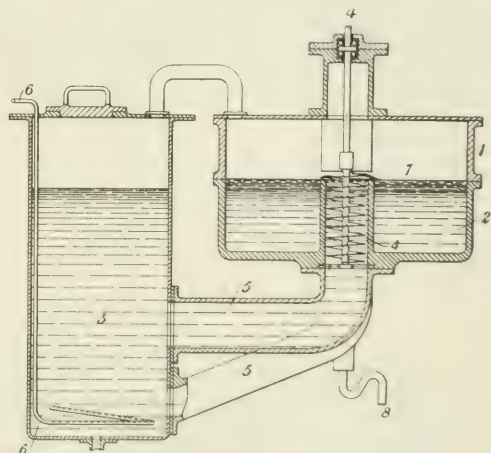


FIG. 8—VERTICAL SECTION OF ELECTROLYTIC CELL

tassium alloys. Amids, cyanamids and cyanides, when brought into contact in the fused state with alloys of the alkali metals will dissolve large amounts of the alkali metals without attacking the other metallic constituent of the alloy. The lead-alkali alloys are preferred in the process. The most economical lead-alkali alloys to be used are those containing 5 per cent sodium or 6 per cent potassium. The temperature at which the alloys must be maintained is 400 deg. C. or more, as below this temperature the reactions taking place are much retarded. The temperature of the fused amid should not exceed 440 deg. C. for sodium and 400 deg. C. for potassium, or otherwise decomposition will take

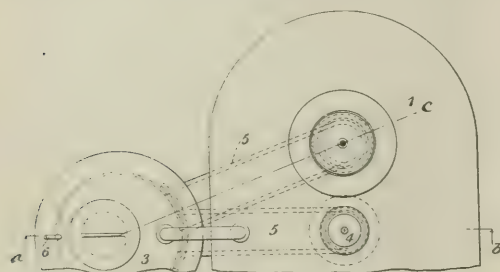


FIG. 9—PLAN OF APPARATUS

place. The one essential condition is, that there should be good contact between the alloy and the fused amid.

The apparatus is shown in Figs. 8, 9 and 10. Fig. 8 is the secondary cell in connection with any electrolytic or other alloy producing apparatus. An electrolytic cell for the production of the alloy is advantageous, as the alloy may then be produced continuously. The alloy 2 circulates through cell 1; 3 is the amid kettle; 4 the pump for circulating the amid and 5 the well and circulating pipes to kettle 3; 6 indicates the inlet pipe for ammonia or the like. The surface of the moving amid or other products is indicated at 7. The alloy for this

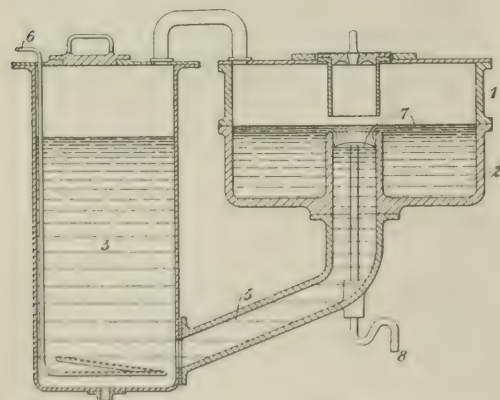


FIG. 10—MODIFIED CELL CONSTRUCTION

process may be produced preferably in an electrolytic cell, this forming the first receptacle of the process, while the above described apparatus constitutes the second one. The whole process then works continuously for the production of amids. Cyanides, cyanamids and other compounds may be produced similarly. (1,197,329, Sept. 5, 1916.)

A Rapid Coal Unloader

The machine shown in the accompanying illustration was designed primarily for unloading cars in which the coal had frozen. It has, however, proven to be a very useful machine at any time of the year as it unloads a 50-ton coal car in 5 to 6 minutes, forcing the coal into the track hopper. The origin of the machine makes an interesting story.

The Edison Illuminating Company of Detroit had for many years experienced considerable difficulty in unloading a sufficient amount of coal to meet the load demand at its power houses during the winter season when the coal had become frozen in the cars. As received by this company during the winter season, the coal is frozen at the top and bottom of the car for a distance of about 2 ft., and often throughout the entire depth of the car. In either case the coal would not flow from the car when the doors were opened and it would be necessary to force an opening by driving a small pipe with a hand hammer through the frozen coal at several places. This operation required from 30 to 90 minutes. After an opening had been made the coal was loosened by picks. The whole work of unloading a car would require from 1½ to 4 hours, depending upon the degree to which the contents were frozen.

Mr. J. P. Cosidine, engineer with the Edison Company, planned and patented the machine as shown here, for speeding up this unloading.

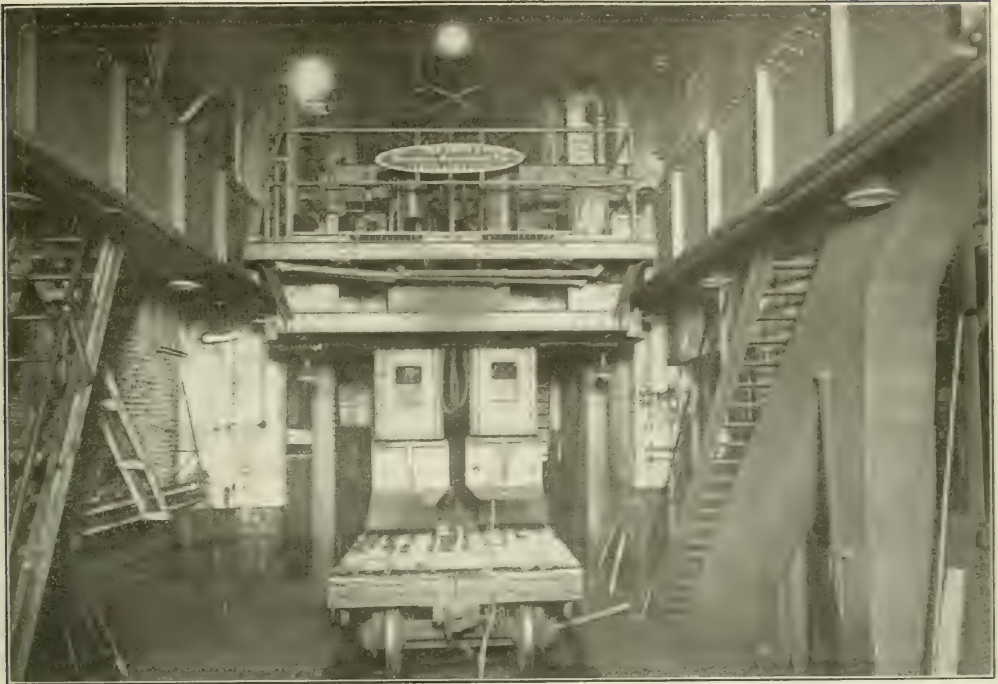
The coal breaker and scraper consists of a carriage supported by, and traveling longitudinally on a girder runway, and two spuds with air hammers carried by the carriage. The carriage, weighing 15 tons, is held in position by four doubled-flanged wheels which run on the top of the runway girders, and is driven by a 22-hp. variable-speed motor through pinions that mesh into racks fastened to the bottom of the girders. Another method for propelling the machine along the runway is by cables dead ended at each end of the runway and connected to the traveling motors on the machine. Either of these arrangements affords a positive drive that does not depend upon the tractive effort of the flanged wheels. The travel motor is provided with a solenoid brake for promptly arresting the high speed parts of the mechanism when the current is shut off. A limit device is also provided for the travel mechanism, to prevent running off the runways. The carriage carries two spuds, each weighing 4½ tons and each hung by a cable.

In the spud above the anvil block there is a double acting air hammer weighing 3400 lb. to which is connected a flexible air hose. The two spuds occupy approximately the full width of the car. One or both may be operated at a time, being raised by one 52-hp. variable speed motor. The hoist motor is provided with a solenoid brake, and there is a limit device to prevent overhoisting.

In the illustration the spuds are shown lowered to a position at which the elevation of the lower ends corresponds to the height of the car floor. When the machine is not operating the spuds are carried at the highest position, the lowest extremity being on a line with the bottom of the carriage.

As shown in the illustration the bottoms of the spuds are cut out at the inner side, thus allowing them to clear the center beam on hopper bottom cars. A small portion of the coal escapes through the opening between the spuds but this is negligible in amount and can be removed quickly with shovels.

When a car is to be unloaded it is placed over the hopper and the doors dropped. If necessary as in the case of frozen coal, the spuds on the machine can start the coal flowing through the doors. The machine is



GENERAL VIEW OF UNLOADER SHOWING SPUDS IN LOWEST POSITION

run to one end of the car and the spuds lowered into the coal and then the machine is run forward scraping the coal toward the doors and dropping it into the hoppers. This is repeated on the other end. As stated before it requires from 5 to 6 minutes to clean the car.

This machine was first put to work in May, 1914, and has been in continuous operation since then. It is now being generally placed on the market by its makers, the Brown Hoisting Machinery Company, Cleveland, Ohio.

The Chemical and the Mineral Industry of French Indo-China

In Tonkin there are at the present time nine tanneries, one situated at Hanoi and owned by La Société des Tanneries de l'Indochine and eight smaller ones in the vicinity of Haifong owned by Chinese interests. The Hanoi establishment used 40,000 hides in 1915 while the Chinese factories used from 15,000 to 20,000. The output of the leather products for the year 1915 amounted to \$100,000.

There is a paper mill at Dapcau and a pulp mill at Vietri, both in Tonkin. Starting operations late in 1914, the paper mill at Dapcau turned out approximately 1200 tons of coarse paper made from rye straw, mulberry bark, bamboo and the like, the product being sold on the local market. The Vietri plant, which produced pulp from bamboo, shut down late in 1914, due to lack of management, and has not been reopened since.

The two soap factories, one situated at Haifong and one at Saigon, turned out approximately 1400 tons of soap in the year 1915. Of this the Haifong plant produced 1200 tons and the much smaller factory at

Saigon 200. The soap produced by the Haifong establishment was valued at \$150,000, which value was raised to \$200,000 by the by-products. These figures show a 100 per cent increase over the year 1914, which was mainly due to the removal of European competition.

The three factories in Anam producing albumen from the whites of duck eggs are: the plant of Derober et Fiard at Hue, consuming approximately 2,500,000 eggs during the two seasons, September-February and March-July; that of Murat at the same place consumes the same amount; and the establishment of Derober et Fiard at Quinhon consumes 10,000,000 per year. The entire production for the year 1915 was 66,138 lb. of dried egg albumen, valued at \$15,000, and 595,248 lb. of liquid egg yolks, valued at \$25,000. This shows a decline of 50 per cent in market value

Articles	1914		1915	
	Metric Tons	Value	Metric Tons	Value
Copper	36,000	\$1,400,000	100,000	\$1,200,000
Zinc	19,562	463,248	100,000	2,000,000
Tungsten	216	112,500	100,000	2,000,000
Antimony	920	30,000	100,000	2,000,000
Sn	29,947	78,000	17,000	60,000
Cement	30,000	120,825	50,000	750,000
Gold ore, grams	184,000	580,000	100,000	500,000

*Estimated.

Notes: The figures given are for two seasons: 1. The first season, usually, and 2. The second season, usually, as determined by the market prices, i.e.: The custom value of coal is 20 francs, or \$3.36 per ton, while the market value at the present time is about 50 francs or \$9.65. Therefore the coal exported for the year 1915 at the actual market price would amount to \$3,500,000 instead of the value given in the table. Similarly for zinc: The custom value for zinc ore is 130 francs per ton or \$25.09, while the actual market price fluctuates around 300 francs or \$57.90. The value of the zinc shipments for 1915 corrected is therefore \$1,930,000. The market prices for tin, tungsten and zinc ores shipped from Haifong is 3 to 10 times as great as the custom figures given above.

from the figures of 1914 and is due to cost of freight and loss of market. The products were generally sent to France, but a large quantity of the liquid egg yolks had, previous to the war, found an outlet in Germany.

The total production of matches in 1915 was 22,000 cases of 7,200 boxes each, valued at \$650,000, and showed an increase of about 10 per cent over the year 1914. This increase is due to the fact that the industry has captured the total French Indo-China market. Two factories are operated by La Société Indochine des Allumettes, one being at Hanoi and one at Ben-thuy, and one at Ham-rong, near Thanh-hoa, is operated by La Société des Allumettes de Thanh-hoa.

The mineral production of French Indo-China may best be shown by a table taken from the Supplement to Commerce Reports, Oct. 16, 1916:

Increasing Stability of Bitumens by Introduction of Colloids

An interesting application of colloidal chemistry is described in patents recently issued to CLIFFORD RICHARDSON, consulting engineer with the Barber Asphalt Company, on an improved bituminous substance and on the process of manufacture (U. S. Patents 1,198,769, Sept. 19, 1916, and 1,198,955, Sept. 19, 1916). Patents have also been granted in several foreign countries. The process consists in the introduction of clay in the form of a colloidal solution into the bitumen in such a way that when the water is subsequently driven off the product has a greater degree of stability than formerly obtainable. The process was discussed in a general way in a paper on "Asphalt" read at the symposium on colloids of the recent New York meeting of the American Chemical Society. The process is applicable to residual pitches from petroleum distillation and coal-tar pitches as well as native bitumens.

It is well known that the addition of finely divided mineral matter to bituminous substances increases their stability, and this knowledge has been used in manufacturing paving materials and in other arts. By the new process a greater resistance to deformation under pressure is obtained. Finely divided clay in the colloidal state, made by combining the clay with water in the form of a paste, is added to the bitumen. With highly colloidal clays three parts of water to one of clay are used. With poorer clays more water is used. The method of adding as given in the specification is as follows:

"This paste is added to a bituminous substance in proportions varying with the character of the substance and the object for which the material is to be used. The amount of disperse colloid should be at least 1 or 2 per cent, but may be increased to any percentage at which the bitumen will melt and flow. But if the proportion of clay is too large, the bitumen is incapable of constituting a continuous phase in relation to the clay, and accordingly instead of matter in a colloidal state there results a mere mixture, which does not constitute my invention. Proper agitation of the paste and the bitumen with steam or air will effect uniform emulsification of the two components. The water with which the disperse colloid has been associated is then removed as by evaporation."

An example of the process as used for making paving material is given as follows:

"I may add to any crude petroleum, maltha or liquid residuum from the distillation thereof, or to any form of bitumen sufficiently liquid below the temperature of boiling water, to make an emulsion with the clay paste,

from 20 to 50 per cent of a liquid paste consisting of water and clay containing disperse colloidal matter, varying in amount according to the quality of the clay, but, of course, the more desirable the larger percentage of this material, although the coarser portion may be looked upon as desirable as an ordinary filler, although undesirable if it is sufficiently coarse to settle out during distillation and thus form a cake or coke upon the walls of the still. This combination is emulsified by passing through it steam or air or by other means of agitation, and evaporating the water, incidentally in some cases distilling off some or all of the more volatile portions of the bitumen, according to the uses to which the resulting residual pitch is to be put in the preparation of asphaltic cements for paving mixtures."

The products resulting from this process have markedly different properties from products in which the mineral matter is introduced as a dry powder. The products vary in strength and range from materials resembling hard vulcanized rubber to stable plastic mixtures suitable for paving and other uses.

Personal

Mr. A. P. Allen, recently with the Calumet & Hecla, has resigned his position, and is now with the Highland Mining Company, at Ashcroft, B. C., Canada.

Mr. J. W. Bumgardner has resigned his position as metallurgist of the Becker Steel Company of New York, and has become associated with the Wheeling Mold & Foundry Co., Wheeling, W. Va., in the roll department.

Mr. H. L. Christensen, formerly mill superintendent at the Miami Copper Co., has accepted a similar position with the Alaska-Juneau Gold Mining Co.

Mr. Nels C. Christensen, recently connected with Bureau of Mines of the University of Utah, has left for southern Utah, to build a mill for the Big Indian Copper Company. The mill will handle low grade, oxidized copper ores, and will be of a new type, embodying the principles of the process devised by Mr. Christensen and H. J. Morgan for handling such ores.

Mr. W. L. Clark has resigned as manager of the United Verde Copper Company, at Jerome, Arizona. His successor is R. E. Tally, for many years connected with the company in the capacity of mines superintendent.

Mr. H. B. Coho, widely known as the former secretary of the New York Section of the American Electrochemical Society, has returned from Lowell, Mass., where he was sent by the United Lead Co. to organize the business departments of the U. S. Cartridge Co., and is now back at his old desk at the United Lead Company's offices at 111 Broadway, New York, in charge of their research work. How well he succeeded at Lowell may be judged from the following quotation from a speech made by Mr. E. H. Schell at a banquet given in Mr. Coho's honor on the occasion of his leaving Lowell. After referring to Mr. Coho's extended welfare work he said: "One of the most prominent men in labor matters in New England made the statement when he heard of Mr. Coho's return to New York that his going would mean a real loss to the Commonwealth of Massachusetts. We cannot keep Mr. Coho in Massachusetts, but we can do our best to maintain the manifold industrial structures which he has reared for our benefit, and we can bid him Godspeed and good luck for the future."

Mr. Sidney Cornell has been appointed heat-treating engineer of the Remington Arms Union Metallic Cartridge Company, Inc., at the Remington Bridgeport Works, and will have supervision of the annealing,

hardening and heat-treating operations, which in future will form a separate department of the company.

Mr. W. R. Degenhardt, metallurgical engineer for the Burma Corporation, Ltd., British Burma, passed through Salt Lake City on an inspection tour of the large mining districts in the western United States.

Mr. J. F. Erisman of Denver, Col., general manager of the Blue Flag Gold Mining Company, has inspected the properties of said company in Idaho.

Mr. A. N. Fox has resigned his position as advertising manager for the Benjamin Electric Mfg. Company and has accepted the presidency of the R. & F. Copper Company of Nevada, with headquarters in the Harris Trust Building in Chicago.

Mr. W. F. Grace, manager of the Waihi Grand Junction mine, New Zealand, has gone to Sidney, Australia, to recover from the effects of a long illness.

Mr. Jay P. Graves of Spokane, one of the managers of the Granby Consolidated Co., has retired as director and his successor is Henry Bruere of New York.

Mr. E. H. Hamilton is the new metallurgical manager for the Trail smelter of the Consolidated Mining & Smelting Co. of Canada.

Dr. Edward Hart has retired as active head of the department of chemistry of Lafayette College, and will be succeeded by Dr. Eugene C. Bingham, professor of chemistry at Richmond College. Dr. Hart will remain connected with the department as professor of chemical engineering, and will also remain in charge of the Henry W. Oliver chemical library.

Mr. E. L. Hiatt, after resigning his position as chief engineer with the Ray Consolidated Copper Company, was made manager of the Arizona Ray Copper Company.

Mr. T. P. Holt, superintendent of the Tintic Milling Company, is back at the plant after a long absence in the South and in the East. At Norfolk, W. Va., Mr. Holt supervised the installation of two of the Holt-Dern roasters, which are now being successfully used at the Virginia Smelting Company.

Mr. Louis D. Huntoon has completed the examination of several mining properties in South Dakota.

Mr. A. W. Jenks is the new smelter superintendent of the Burma Mines Corporation, Ltd., in British Burma.

Mr. W. C. Madge, connected with the Irytsh Corporation, Ltd., arrived at Spokane in the middle of October from the Ridder mining concessions in Siberia. He expects to stay in the United States about one month, and will then sail for the company's headquarters at London.

Mr. W. O'Neil has been appointed general manager of the Janet Copper Mining & Milling Co., located near Vernal, Utah.

Mr. E. L. Newhouse paid a visit to the Butte-Duluth property at Butte.

Dr. L. D. Rickets has been traveling through Arizona, inspecting various copper properties.

Mr. L. C. Schultz has joined the staff of Hamilton & Hansel, 17 Battery Place, N. Y., agents for the Rennerfelt electric furnace.

Mr. J. C. Simmons, manager of the Rare Metals Mining & Milling Co., at Telluride, Col., has visited New York City on company business.

Mr. F. Steffer is supervising the construction of a new custom mill of 500 tons daily capacity at Chloride, Ariz.

Mr. E. Gybbon Spilsbury has gone to Cuba on professional work and will be absent about three weeks.

Mr. M. J. Welch has returned to Los Angeles, Cal., after having supervised the construction of an experimental concentrator for the Cerro de Pasco Company in Peru.

Mr. Norman L. Warford, who has been in charge of the powdered coal department of the Anaconda Copper Mining Company, Anaconda, Mont., has become connected with the Powdered Coal Engineering & Equipment Company of Chicago, Ill., in the capacity of engineer in charge of construction. Mr. Warford is credited with having installed the largest powdered coal plant in the United States, for the Anaconda Copper Mining Company at its several works, wherein they burn approximately 1000 tons of pulverized fuel every day.

Obituary

William Cooper Cuntz, general manager and director of the Goldschmidt Thermit Company, New York, died on Thursday morning, Nov. 2, 1916, at Auburndale, Mass., where he was on a visit for the benefit of his health which was impaired by an operation for appendicitis a year ago. Mr. Cuntz was the son of the late Emil A. H. Cuntz and Frances Cooper Cuntz and was born at Hoboken, N. J., in 1871. He attended the Hoboken Academy and Stevens Institute of Technology, graduating in 1892 with the degree of mechanical engineer. He then became connected with the Pennsylvania Steel Company of Steelton, Pa., first with the bridge and construction department and later with the sales department, which he represented in many important capacities in Boston, Philadelphia, London (England) and in Steelton. In 1910 he severed his connections with the steel company to become a director and the general manager of the Goldschmidt Thermit Company of New York. At the time of his death he was also a director of the Goldschmidt Detinning Company.

David Colville, managing director of David Colville & Sons, Ltd., English steel manufacturers, was taken ill in his office at Motherwell, England, on Saturday, Oct. 14, and died at his residence in Motherwell the following Monday.

Book Reviews

Catalysis and Its Industrial Applications. By E. Jobling. Duodecimo (12 x 15 cm.), 120 pages, 12 illustrations. Price, \$1.00. Philadelphia: P. Blakiston's Sons & Co.

This is a reprint from "The Chemical World." Revision and extension were prevented by the author enrolling in the British Army, so the reprint is verbatim. It is a useful and informing little book. We wish it had been longer, since it is written with a full command of the available facts and theories, and as much definiteness as the present state of science will permit.

* * *

The Corrosion of Iron. By L. C. Wilson. Duodecimo (12 x 19 cm.), 178 pages. Price, \$2.00. New York: The Engineering Magazine Co.

A brief but clear statement of the general aspects of the problem. It will be useful to the general reader, or as an introduction to the larger works of Cushman or of Friend. About half the book is a discussion of external preventive measures, but the influence of composition (manganese, copper, carbon, etc.) and the theories of corrosion are skilfully summarized.

INDUSTRIAL

Financial and Construction News

Financial

The Acton Oil & Gas Company, Nashville, Tenn., has been incorporated with a capital of \$25,000. The incorporators are G. M. Whiteson, Jacob Piere, D. B. Snyder and others.

The American Graphite Company, Gadsden, Ala., has been incorporated with \$100,000 capital to mine graphite.

The American Kelp & Chemical Industry, Inc., has been incorporated with a capital of \$100,000. Incorporators are Frank Messedate and C. H. Grimstad.

The American Mixing & Beating Machine Company, Inc., Brooklyn, N. Y., has been incorporated with a capital of \$50,000 to manufacture mixing machines. The incorporators are J. Trust, F. P. Roth, H. Fischer.

The Atlantic Dye stuff Company, Boston, Mass., has been incorporated with a capital of \$50,000. Incorporators are Montgomery Reed, Albert C. Burrage, Jr., Thomas W. Nason.

Atlantic Paper & Pulp Corp. has been incorporated with a capital of \$250,000 to manufacture paper pulp. The incorporators are M. T. Nicholas, D. T. Wells, R. N. Sheffy, of Glen Ridge, N. J.

The Belmont Petroleum Company, Tulsa, Okla., has been incorporated with a capital of \$15,000. Incorporators are T. L. Brown, A. L. Poole, D. C. Tucker and T. B. Hodgden.

The Blossburg Mining Co., Cardiff, Ala., has been incorporated with \$2,000 capital. The officers are: William Robson, president; Tom M. Dickey, vice-president; and P. H. Jordan, secretary-treasurer.

The Bodine Chemicals & Color Co., Inc., has been incorporated in New York State with \$10,000 to engage in business in chemicals, dyes, etc. Incorporators are G. Feinberg, E. D. Holland, A. C. Horvath.

The Bridgewater Chemical Company has been incorporated in Delaware to manufacture chemicals. Capital, \$200,000.

The Brightwood Oil Company, Indianapolis, Ind., has been incorporated with a capital of \$50,000 to drill for oil and gas. The incorporators are Horace W. Nordyke, Erwin H. Sheil, Gilbert P. Inman.

The Camel Oil Corporation, Oklahoma City, Okla., has been incorporated with a capital of \$25,000. Incorporators, A. A. Zalondek, J. Gerald Marz and D. K. Pope.

The Canton Oxygen & Hydrogen Company, Pittsburgh, Pa., has been incorporated in Delaware with a capital of \$200,000 to manufacture and deal in oxygen and other chemicals. Incorporators are F. H. McCarthy, C. W. Mely, J. H. Haverly, all of Pittsburgh.

The Carlton Manufacturing Company, Portland, has been incorporated with a capital of \$150,000, par \$100. The officers are: Frederick E. Robinson, president; treasurer, Raymond S. Oakes; clerk, Robert T. Whitehouse.

The Carolina Products Company, Bandana, N. C., has been incorporated with a capital of \$100,000 to engage in mining timber.

The Chattanooga Mirror Works, Chattanooga, Tenn., has been incorporated with a capital of \$25,000 to manufacture mirrors and other glass products. The incorporators are Carl Grau, Otto J. E. Baugh, W. A. Aultman, J. M. Mitchell, G. C. Roul.

The Cheboygan Paper Company, Cheboygan, Mich., has been sold to the Union Hag & Paper Company. Majority control was obtained at a cost of \$1,550,000. The Union Hag & Paper Co. is capitalized at \$2,000,000 and manufactures paper bags in various parts of the country.

The Chicago Glass Products Co., Chicago, Ill., has been incorporated with a capital of \$50,000. The officers are: George A. Leavy, Ida Miller, Thomas M. Whitton.

The Chicago National Trust Company, Ltd., has been incorporated in the state of Illinois to carry on the business of a trust company, and the Cooper Mfg. Co., of Bennington, Vt., have been purchased by the Hink Cat Tractor Co., of Chicago, Ill. The latter company is capitalized at \$1,000,000 and manufactures tractors.

The Commercial Chemical Company, Inc., New York City, has been incorporated in

New York State with a capital of \$90,000. The incorporators are N. R. Green, G. E. Mosset, D. I. Straus, of Aeolian Hall, New York.

The Consolidated Rolling Mills & Foundries Company, Inc., Wilmington, Del., has been incorporated with a capital of \$1,000,000; representative, Geo. D. Wright, 25 Broad Street, New York.

The Continental Refining Company, Bristol, Okla., has been incorporated with a capital of \$1,300,000.

The Creighton Valve Company, Inc., Maspeth, L. I., has been incorporated with a capital of \$15,000 to deal in metal valves. The incorporators are G. S. Jervis, R. Kunze, W. L. Woodhill, 26 Ely Avenue, Long Island City.

The Crude Oil Producing Company, Dover, Del., has been incorporated with a capital of \$500,000 to buy, sell and lease oil and gas lands. Incorporators are F. D. Buck, M. L. Harty, K. E. Longfield, Wilmington, Del.

The Decatur Straw Board Company, Decatur, Ind., has been incorporated with a capital of \$25,000 to manufacture straw board paper, etc. The incorporators are John W. Vail, Dan R. Vail and F. E. Vail.

The Deeds Commercial Laboratories, Indianapolis, Ind., has increased its capital stock from \$10,000 to \$50,000.

The Dissoway-Schad Company, Brooklyn, N. Y., has been incorporated with a capital of \$14,000 to manufacture chemicals. The incorporators are Thurston N. Dissoway, Frank N. Lesinsky.

The Eagle Chemical Works, Inc., has been organized with \$10,000 capital to manufacture printing and lithographing materials, inks, etc. The incorporators are A. Katz, J. J. Murray and J. Frank, of 792 East 175th Street.

The Eastern Oil Company, Cleveland, Ohio, has been incorporated with a capital of \$10,000. The incorporators are E. L. Wall, P. A. Wall, C. D. Woodyatt, E. L. Woodyatt, R. T. Morrow.

The Electro-Amalgams Corporation, New York, N. Y., has been incorporated with a capital of \$5,000 to establish a system for the electro-chemical purification of water and other processes. The incorporators are E. O. Towne, H. W. German and B. B. Cromble, 169 West 80th Street, New York.

The Elem Asphalt & Oil Company, Kansas, with a capital of \$400,000, has been authorized to conduct business under the laws of Missouri.

The Enterprise Foundry Company, Wilmington, Del., has been incorporated in Delaware with a capital of \$50,000 to carry on the business of operating foundries, etc. The incorporators are John Myers, Louis A. Hillersohn, William H. Myers, all of Wilmington.

The Federal Color & Chemical Co., Boston, Mass., has been incorporated with a capital of \$25,000. The directors are Benj. A. Levy, president; Samuel Markell, treasurer, and E. M. Batts.

The Flash Chemical Company, Greenville, S. C., has been incorporated with a capital of \$1,000. The incorporators are L. W. Arrington, M. C. Westervelt and E. G. Fowler.

The Friars Chemical Company has been incorporated in Delaware with \$500,000 capital by G. E. Fooks, K. M. Dougherty and L. S. Dorfe of Wilmington.

The General Coal Tar Products Company has been incorporated in New York State with \$50,000 capital by S. A. Davison of Rockville Center, C. E. Abrams of East Patchogue, and J. H. Gaultins of Long Beach.

The Gilliland Oil & Gas Company, Dover, Del., has been incorporated with a capital of \$8,000,000 to deal in oil and gas. The incorporators are J. L. Skinner, H. E. Latter and H. G. Coffin.

The Grace Nitrate Company, Dover, Del., has been incorporated with a capital of \$1,000,000 to explore for caliche or nitrate. The incorporators are M. M. Hirona and I. E. Bels.

The Greenstone Refining Company has been incorporated in Delaware to acquire and develop oil and mineral land. Capital

\$500,000. Incorporators, F. D. Buck, M. L. Harty, K. E. Longfield, of Wilmington, Del.

The Hammerill Company, Erie, Pa., has been incorporated to manufacture paper by W. P. Clifford, Albert O. Chapin and Henry E. Fisk.

The Hennepin Copper Company, Portland, Me., has been incorporated with a capital of \$1,000,000 to manufacture and deal in all kinds of ores, metals and minerals. The incorporators are Joseph W. Hawes, Boston, Mass.; Robert T. Whitehouse, John E. Thomas, Portland, Me.

The Henry-Miller Foundry Company, Canton, Ohio, has been incorporated with a capital of \$150,000. The incorporators are Thomas E. Henry, Charles J. Miller, Elmo S. Moncrief, Jacob W. Steiner, James K. Lynch.

The Howland Pulp & Paper Corporation of Brattleboro, Vt., has increased its capital stock from \$50,000 to \$300,000.

The Hudson Trading & Investment Company has been incorporated in Delaware to acquire and develop property. The incorporators are J. C. Williamson, London, Eng.; E. R. Cleaver and A. P. Hallett, New York City.

The Hygienic Products Company, Wilmington, Del., has been incorporated in Delaware with a capital of \$100,000 to prepare and compound chemicals, drugs, etc. The incorporators are Herbert E. Latter, Norman P. Coffin, Clement M. Egner, of Wilmington.

The International Potash & Fertilizer Company, Los Angeles, Cal., has been incorporated. Their intention is to build a factory for the production of potash from kelp. Organized by R. S. Oppenheim and others.

The Johnstown Paint & Glass Company, Johnstown, Pa., has been incorporated with \$25,000 capital by H. K. Watson of McKeesport, Harry M. Stull and Joseph Ginsberg of Johnstown, and E. K. Collingwood of Pittsburgh.

The Kelly Fertilizer & Oil Mill Co. has been incorporated in Delaware with \$25,000 capital. The incorporators are F. D. Buck, M. L. Harty and K. E. Longfield, of Wilmington.

The Kentucky Oil & Gas Company has been incorporated in Delaware with a capital of \$250,000 to develop the Kentucky oil fields. The incorporators are Samuel Reiner, Jesse Cohen and John Papulias. Valuable leases in Knox County, Ky., have been secured and wells will be sunk. The Kentucky fields were abandoned years ago on account of the low price of crude oil.

The Lighthouse Oil & Refining Company, New York, has been incorporated with a capital of \$1,000,000 to produce petroleum products. The incorporators are Charles Lighthouse, Maurice Cohen and William J. Shalvey.

The McCausland Engineering Company, Delaware, Del., has been incorporated in Delaware with a capital of \$3,000,000 to manufacture iron, steel and other metals and to do a general mechanical engineering business. The incorporators are George H. B. Martin, S. C. Seymour, all of Philadelphia.

The Maryland Tube Corporation, Baltimore, Md., has been incorporated with \$500,000 capital and plans the erection of a tube, bar and sheet mill and brass foundry in Baltimore. The incorporators are Herbert B. Stimpson, Charles H. Birmingham and Heyward Taylor.

The Mercantile Paper Products Company, Bronx, N. Y., has been incorporated with a capital of \$5,000. The company manufactures paper products and compounds. The incorporators are E. Goldman, L. and E. M. Geiger, 819 Manida St., Bronx.

The Mirlolke Manufacturing Co., Inc., is a new company organized in New York with \$100,000 capital to manufacture polishes, chemicals, etc. Incorporators: G. Schnoor, G. Stove and T. H. Moech, 2734 Kingsbridge Terrace, Bronx.

The Monster Chief Mining Company, Wilmington, Del., has been incorporated with a capital of \$2,000,000 to conduct mining operations. The incorporators are M. L. Rogers, L. A. Irwin, Harry W. Davis, Wilmington, Del.

The Mount Alry Coal Company, of Martinsburg, Pa., has been chartered in Delaware to carry on a general mines and collieries business and to manufacture coke. Capital \$200,000. Incorporators: F. M. Miller, H. H. Adlin, MacDonald, N. Y., and Clara T. Ledig, Mahaffey, Pa.

The New York Zinc Company, Wilmington, Del., has been incorporated with a capital of \$1,000,000 to manufacture and sell zinc ores, etc. The incorporators are M. P. Coffin and C. M. Egner.

The Pacific Metals Corporation New York City, has been incorporated with a capital

of \$100,000 to conduct dredging and mining, etc. The incorporators are E. M. Allen, S. B. Howard, L. H. Gunther, 28 Nassau St.

The Painted Post Oil, Gas and Mineral Corporation, Painted Post, N. Y., has been incorporated with a capital of \$5,000 to deal in oil, coal, etc. Incorporators are W. Cumsiky, R. B. Auyers, A. Bevier, of Painted Post.

The Pan-American Mica Company, Inc., Wilmington, Del., has been incorporated to mine and import mica and other minerals with a capital of \$250,000. Representative, Samuel F. Frank, 170 Broadway, New York City.

The Panther Oil Company, Wichita Falls, Kan., has been incorporated with a capital of \$25,000. Incorporators: Charles W. Bean, Frank Kell, C. C. Wood and I. Mackowitz.

The Pike Coal and Coke Company, Pittsburgh, Pa., has increased its capital stock from \$1,000,000 to \$5,000,000.

The Rau Oil & Gas Co., Oklahoma, Okla., has been incorporated with a capital of \$500,000 to prospect for oil. The incorporators are Joe Williford, G. N. Otey, Max Rau.

Raybestos Company, Bridgeport, Conn., has filed a certificate of incorporation in Connecticut.

The Reade Manufacturing Company, Hoboken, N. J., has been incorporated in New Jersey with a capital of \$2,000 to manufacture and deal in all kinds of chemicals. The incorporators are W. J. Reade, Jane E. Reade, Charles H. Reade, 1023 Grand St., Hoboken, N. J.

The Rex-Mar Oil and Gas Company, Parkersburg, W. Va., has been incorporated with a capital of \$10,000. Incorporators: J. M. Connelly, R. G. Stiles, F. H. Rexroad and others.

The Richmond Flats Gold Mining Company, Butte, Mont., has been incorporated in Montana with a capital of \$500,000. The incorporators are W. A. Reel, J. W. Stiver, W. Lamb, W. C. Sider, F. J. Furman. The property of the company is located near Norris, and the office will be in Butte.

The Schell Chemical Company, of New York City, has been organized with a capital of \$15,000. Edward Schell, of West Rockaway, is one of the directors.

The Seven Eleven Oil and Gas Co., Tulsa, Okla., has been incorporated with a capital of \$125,000. Incorporators: F. J. Sullivan, L. W. Mason and Harry Magoffin.

The Sheep Mountain Mining Company, Dover, Del., has been incorporated with a capital of \$1,000,000. The incorporators are L. L. Cowan, R. Montgomery, D. J. Carter, of Chicago, Ill.

The Silk Printing and Dyeing Works, Inc., Bronx, N. Y., has been incorporated with a capital of \$10,000 to dye and convert silks, cotton, etc. The incorporators are N. N. Goodman, J. M. and H. Goodman, 1218 Boston Road, Bronx.

The Solvay Process Company, of New York, has filed a copy of its articles with the Secretary of State of Utah in order that it may transact business in that state in the development of the potash and salt fields. The headquarters in Utah will be in the Kearns Bridge Salt Lake City.

The Star Refining Company, Yale, Okla., is a new incorporation with a capital of \$20,000. Incorporators: R. M. Garner, A. B. Post and H. P. Barnett, of Yale, and E. E. Ryan, of Marana, Okla.

The Stebbins Oil and Gasoline Company, Tulsa, Okla., has been incorporated with a capital of \$750,000. Incorporators: M. F. Powers, G. C. Stebbins and C. A. Steere.

The Super-Six Oil Company, Pond Creek, Okla., has been incorporated in Oklahoma with a capital of \$100,000. The incorporators are F. J. Contry, Ben W. Bird, J. H. Ullman, of Pond Creek.

The Texona Oil Company, Atlanta, Ga., has been incorporated with a capital of \$5,000. Incorporators: J. H. Snipes, A. D. Marrs and R. G. Cooper.

The Titan Chemical Company, Cleveland, Ohio, has increased its capital from \$1,000 to \$200,000.

The Toyah Valley Sulphur Company, Houston, Tex., has been incorporated with a capital of \$130,000. Incorporators: J. A. Daniel, of Houston; G. A. Plummer, of Beaumont, and A. A. Snell, of Toyah, Tex.

The Transport Oil Corporation, 43 Cedar St., New York City. Capital \$20,000. Deal in produce, coal, coke, chemicals, etc. The incorporators are R. E. G. Cord, J. A. Lederman, B. Lockwood.

Transue & Williams Steel Forging Corporation, New York, has been incorporated with a capital of \$550,000 to manufacture and deal in metals, steel forgings, etc. The

incorporators are E. L. Durken, W. J. Dwyer, Jr., R. Bennett.

The United Alloy Steel Company of New York has been authorized to engage in business in Ohio by the secretary of state of Ohio.

The United Oil Company, Wilmington, Del., has been incorporated in Delaware with a capital of \$500,000 to refine and distribute crude oil and its products. The incorporators are M. L. Rogers, L. A. Irwin, Harry W. Davis, all of Wilmington.

The Usoline Products Corporation has been incorporated in New York State with \$500,000 capital. Business, oil refining. Incorporators: H. Rudolph, J. J. Bueb and P. O. Hoening, 220 Cathedral Parkway.

The Velve Copper Company, Dover, Del., has been incorporated with a capital of \$500,000 to acquire and develop mining rights. The incorporators are Arthur W. Bryan, Samuel P. Howard and L. H. Gunther, of New York City.

The Westerly Dye Works, Westerly, R. I., has been incorporated with a capital of \$100,000 to do business in the plant of the Pequot Shirt Company at Westerly.

The Wharton Steel Company, owner of extensive iron ore deposits and three blast furnaces in northern New Jersey, is reported to have been purchased by J. L. Replogle, vice-president of the American Steel Company, and associates whose names have not yet been made public. The new owners intend to develop the properties extensively and to install by-product coke ovens. About 5000 acres of iron ore lands, of which the Wharton mine is the largest, are included in the deal.

The Whitley Oil Company, Tulsa, Okla., has been incorporated with a capital of \$10,000. Incorporators: Roy R. Poe, Ivan L. Jackson and Earl T. Miller.

Construction and Operation

Alabama

ANDALUSIA.—The Southern Cotton Oil Co. will build a new plant, recently burned, at a cost of \$50,000.

BIRMINGHAM.—Former Governor O'Neal is understood to have gone to Montgomery with a delegation from the Board of Trade to attend a meeting of the U. S. Chamber of Commerce in order to urge the location of the Government nitrate plant at Muscle Shoals.

Arizona

CHLORIDE.—The Zinc Concentrating Co. is negotiating with owners of zinc properties at Rico and Chloride for the purpose of erecting a plant at Chloride for the treatment of ore in that locality.

JEROME.—George Mitchell, of Jerome, contemplates erecting a 1000-ton smelter, to cost \$500,000.

MAYER.—The Great Western Smelters Corporation plans the erection of a 1000-ton copper smelter. Ernest Le Duc is president of the company.

MAYER.—The Stoddard Milling Co. expects to double the capacity of its flotation plant treating copper ores. This will bring the capacity up to 300 tons.

OATMAN.—The Big Jim Gold Mining Co. plans the erection of a large reduction plant to treat gold ores. A. G. Keating is manager of the plant.

PRESCOTT.—The Cash Mines Co. expects to install a 100-ton flotation plant to handle gold ores. N. H. Getchell is manager.

PRESCOTT.—The Maricopa Queen Oils Co. plans the erection of a reduction plant to treat gold ores at the New State mine. W. S. Wilhelm is manager of the company.

California

LONG BEACH.—The Long Beach Chemical Company will enlarge its plant on property leased from the Los Angeles Docks & Terminal Company. The plant will be located near the American Products Co., and Lorin Manufacturing Company.

LOS ANGELES.—The Pacific Coast Horax Company and the Solvay Process Company are reported to have in contemplation the joint erection of a large plant on San Diego, La., in San Bernardino County, to produce potash, soda and borax from lake. Victor Barndt, of Tonopah, Nev., president of the Nevada Chemical Co., expects the financial interests which have been seeking to arrange for the operation of the plant under the mineral land leasing bill.

MAINTINEZ.—The Steel Co. of California will begin work shortly on the construction of a large steel mill at the site of the old mill, at the subject. The capacity will be one-third.

NEWARK.—A new steel mill will be constructed at Newark, N. J., on a 100-acre site. The company will greatly increase its output of salt by this new addition.

OAKLAND.—The Pacific Coast Steel Company is preparing to build the first stage of a new mill, to erect a new mill at Oakland.

SAN PEDRO.—Reported that the United States Company is erecting a new steel mill at a \$2,000,000 refinery.

Delaware

WILMINGTON.—The Wilmington Leather Company has let the contract to Joyce and Kitchin, for an addition to the plant, 10 stories high and 40 by 200 feet. The capacity of the plant will be doubled.

Illinois

CHICAGO.—The Sinclair Oil and Refining Corporation has acquired a site in East Chicago for the erection of a refinery. The property is convenient to rail and water. An 8-in. pipe line, 800 miles long, will supply oil to the refinery from the Kansas and Oklahoma fields. The refinery will be complete in every detail and when finished will have a capacity of 10,000 barrels per day. The company is also considering the erection of refineries on the Mississippi River and at Kansas City. Work on the pipe line has been commenced.

ROCK ISLAND.—The Illinois Oil Company has begun the erection of its new \$50,000 paint factory, adjacent to its present plant. All lines of paints will be manufactured and the capacity will be 10 cars per week.

Iowa

DAVENPORT.—The Sinclair Oil & Refining Company is planning the erection of a large refinery on the Mississippi River. Davenport, Rock Island, Port Madison and Keokuk are all under consideration for the site.

DUBUQUE.—The Dubuque Tanning and Leather Company has completed a new plant at which all the company's tanning and manufacturing will be carried out. F. M. Homburg is president.

PORT MADISON.—The American Fork & Hoe Company has awarded the contract for a new plant, to cost \$100,000.

Kansas

CROWLEY.—The Kawfield Oil Company, capitalized at \$50,000, has started drilling on one of its locations near Crowley.

Louisiana

NEW ORLEANS.—The Sugar Cane By-Products Company has purchased the Gehlert shingle mill property, owned by the Norris Lumber Company, of Houston, Tex., and will begin the remodeling of the property and the installation of machinery for paper, pulp, and for working up bagasse, cotton stalks and rice straw. A chemical factory will be erected in conjunction with the paper mill to produce alcohol from bagasse. The cotton stalks, rice straw and bagasse were formerly useless, except as a low grade fuel for some purposes.

NEW ORLEANS.—Morris & Co., of the Chicago meat packers, plan the erection of an addition to their plant, to cost \$100,000.

NEW ORLEANS.—The Stern Foundry & Machinery Company, 1630 Annunciation Street, is preparing plans for plant additions, to cost \$100,000.

Maryland

BALTIMORE.—The Maryland Chemical Company, successors to the New Spar Chemicals Company, has purchased the Columbia Avenue and the B. & O. Railroad, on which chemical factories will be erected. Several large buildings and a warehouse will constitute the group, in which the company will produce and store chemicals. Samuel H. Brundage is president and Edward F. Brundage is secretary.

Massachusetts

MANCHESTER.—The New England Druggists Steel Company plans the erection of a plant here, to cost \$250,000.

Michigan

DETROIT.—The Michigan Paper Company has been sold to the Union Bag & Paper Corporation, and it is expected that the plant will be enlarged and new machinery installed.

PETOSKEY.—The paper mill here, which is a branch plant of the West Paper Company, of Milwaukee, Ind., will continue to operate.

tions as soon as repairs can be made and new buildings erected. Fire recently stopped work at the plant. The town will furnish free electric power for six months in order to give the company an opportunity to erect a fireproof power plant.

Minnesota

GRAND RAPIDS—The Itasca Paper Company has begun the erection of additions and improvements to its plant, which will increase its capacity 20 per cent. The machinery has already been purchased.

MINNEAPOLIS—The Mueller Furnace Company contemplates the erection of a \$70,000 factory.

Mississippi

HATTIESBURG—Work will be commenced shortly on a new \$1,000,000 paper mill, to be finished by Jan. 1, 1918.

Missouri

KANSAS CITY—The Nourse Oil Company will build a \$100,000 plant for manufacturing oil specialties.

VALLEY PARK—The St. Louis Plate Glass Company has opened bids for the construction of a new glass plant, to cost approximately \$120,000.

Montana

HAVRE—A campaign will soon be started by the Chamber of Commerce, to raise \$30,000 with which to start a Farmers' Co-operative Flax Mill.

HELENA—The Montana Testing & Engineering Company will erect an ore mill, to cost \$30,000.

Nebraska

OMAHA—Morris & Co. is erecting a new fertilizer plant at twenty-eighth and P streets, to cost \$40,000.

New Jersey

NEWARK—The Lister Agricultural Chemical Company will erect a new bone block building, to cost \$12,000.

New York

BAKERS FALLS—The Union Bag & Paper Company plans the erection of a four-story paper mill.

BUFFALO—The Kelly Island Lime & Transport Company, of Cleveland, Ohio, has awarded the contract to the Forest City Steel & Iron Company, Cleveland, Ohio, for a limestone crushing and storage building on the Buffalo River and Buffalo Creek Terminal Railroad. The cost of the equipment is estimated at \$250,000.

COLLEGE POINT, L. I.—The American Hard Rubber Company is erecting an addition to its plant to take care of increased business. About 200 more persons will be employed.

GLENS FALLS—The International Paper Company plans the erection of a hydroelectric power plant at Glens Falls. The contract has been let to the H. P. Cummings Construction Company, of Ware, Mass.

LONG ISLAND CITY—The Francos-Smyth Dyes & Color Company, of Virginia, has bought on the U. S. Coal Tar Products Company and will manufacture dyes and chemicals.

NEWBURGH—The Fabrikoid Company is planning the erection of a large dyehouse, which will be larger than the present one. The company has a contract with the Clearfield Rubber Company, of Clearfield, Conn., to do all that company's dyeing.

NIAGARA FALLS—The Isco Chemical Company's new plant has been completed at a cost of \$450,000 and will manufacture caustic soda and bleaching powder.

NIAGARA FALLS—The National Carbon Company has awarded the contract to the Snyder-Gillett Construction Company, of Niagara Falls, for erecting a \$50,000 factory.

NIAGARA FALLS—The Titanium Alloy Manufacturing Company has awarded the contract to the Peckham Construction Company, of Buffalo, for five 2-story factory buildings to cost \$75,000.

POUGHKEEPSIE—The Melroe Plow Company has announced plans for the erection of a large addition to its foundry at a cost of \$20,000. The contract for the construction has been let.

WOODSIDE, L. I.—The Holiday-Kemp Company, Inc., of 90 William Street, Manhattan, has bought the main building of the Consumers' Brewing Company at Woodside, and will begin the manufacture of dyes and chemicals early in November.

Ohio

CLEVELAND—The Columbia Axle Company, of Cleveland, is having plans prepared for a factory on East 33d Street, to cost \$250,000.

CLEVELAND—The National Acme Manufacturing Company is having plans prepared for a new \$300,000 plant.

CLEVELAND—The National Artificial Silk Company has filed plans for the erection of a \$55,000 building at Walford Road and Big Four Railroad.

COLUMBUS—The Columbus Mill and Mine Supply Company is having plans prepared for a new combination warehouse and structural steel plant.

DAYTON—The Duriron Company has purchased ground in which to erect an addition to its foundry.

DOVER—A \$600,000 cold-rolled steel plant will be erected here by a company headed by Herbert C. Greer, of Morgantown, W. Va.

MCDONALD—The Carnegie Steel Company is expected to shortly award the contract for furnishing machinery and equipment for the new McDonald mills. Machinery builders in Youngstown are seeking this contract. The machine shop of the new mills is already completed.

WARREN—The Warren Mazda Lamp Company will erect an addition to its plant at a cost of \$75,000. The contract has been awarded.

WARREN—The West Side Electric Works plans the erection of a large addition to its lamp division in order that the greatly increased demand for lamps can be taken care of.

Oklahoma

CHELSEA—The Marion Refining Company, of Claremore, Okla., is considering the erection of a refinery. A. M. White is president of the company.

OKLAHOMA CITY—The Consumers' Refining Company will erect a chemical plant, to cost about \$250,000. James A. Jones is president. The company is in the market for various equipment, such as filter presses, tanks, etc.

OKLAHOMA CITY—The Oklahoma Oxygen Company, a new incorporation with \$1,000,000 capital, will erect a plant for the manufacture of oxygen.

Pennsylvania

BETHLEHEM—The Bethlehem Steel Co. issued a circular Oct. 30, announcing that it will spend \$50,000 in additions to the plant which it purchased from the Pennsylvania Steel Co. Additional furnaces will be built at Steelton and Sparrows Point.

DUBOIS—The Reliance Glass Factory has resumed operations under new management and is looking forward to a prosperous year. Glass is in good demand and high wages are being paid. The glass industry in general is rapidly assuming a flourishing condition. About 175 men will be employed at this plant. The cost of production has materially increased, due to the increased cost of raw materials and labor and glass prices will be increased accordingly.

KANE—The plate-glass industry is enjoying a period of great prosperity, chiefly because of the large export demand. Many of the manufacturers in this section have increased their capacity by erecting additional furnaces. The American Plate Glass Company recently completed two new furnaces and they are now in operation. The price of plate glass has advanced 40 to 50 per cent during the last twelve months due to increased wages and cost of raw materials.

MARCUS HOOK—Worth Brothers, who last year sold their steel plant in Coatesville to the Midvale Steel and Ordnance Company, have acquired 470 acres of farm land below Marcus Hook. The land is in Delaware, on the Delaware River, just below Pennsylvania State line, and it is the intention to erect a \$15,000,000 steel plant. Norman R. Entekin will supervise the erection of the mill, which will be close proximity to the large shipbuilding plants.

MEDIA—The old Bridgewater Mills near Upland and Chester have been leased by a firm from New York, which will remodel the plant and begin the manufacture of chemicals.

NEW CASTLE—The U. S. Steel Corporation is planning to use a large quantity of flue dust which has accumulated at its Farrell and New Castle works. Sintering plants will be erected and the dust will be used in the blast furnaces.

PHILADELPHIA—The Dill & Collins Company, paper manufacturers, has purchased a group of factories adjoining its plant in Tioga from the Berg Company, and will remodel them.

PITTSBURGH—The Atlantic Refining Company plans the erection of a 13-story building, to cost \$1,000,000. W. G. Wilkins & Company are preparing the sketches.

SHARON—The American Steel Foundry Company will enlarge its Sharon plant by the construction of two additional open hearth furnaces. The company now has

five open hearths in operation. The two new ones will be of 40-ton capacity and will use oil fuel.

Rhode Island

PROVIDENCE—The Royal Chemical Company has taken over the business of the Pawtuxet Valley Dyeing Company and will take up the bleaching and dyeing of yarns and textiles.

South Carolina

COLUMBIA—The State Press Association discussed the high cost of paper at a recent meeting and decided to hold another meeting to take up the question of erecting a paper mill. D. R. Baker, of Hartsville, will be present to discuss opening a plant at Hartsville.

Texas

DALLAS—The Texas Iron and Steel Company, which controls large tracts of East Texas iron ore lands, has acquired the rights to use a new process of iron ore reduction from the U. S. Reduction Company, of Chicago, a new company. Natural gas is used as the reducing agent instead of the coke in the process, which is the invention of Charles S. Bradley, well known as a pioneer in connection with the Bradley-Lovejoy nitrogen fixation work tried on a large scale at Niagara Falls a number of years ago. The United States Reduction Company controls the rights to use the Bradley iron reduction process in the United States.

FORT STOCKTON—The Calumet & Arizona Sulphur Company is prospecting a sulphur deposit near this place. The company's intention to manufacture sulphuric acid.

Utah

OGDEN—The Western Foundry & Machine Company will erect a \$100,000 foundry as an addition to its plant.

Washington

NORTH YAKIMA—The Utah-Idaho Sugar Company will erect a sugar plant to make beet sugar, to cost \$1,500,000. Thomas R. Cutler is president.

SEATTLE—The American Can Company's new plant is progressing nicely. The plant will cost \$500,000 when all completed.

SEATTLE—Options have been taken on iron deposits off the coast of Southeastern Alaska and British Columbia by capitalists who are believed to have in mind the erection of a large iron and steel industry in the Pacific Northwest. Steel-working and shipbuilding interests would become independent of the East if the large developments rumored should take place. Both Seattle and San Francisco are being seriously considered.

West Virginia

PADEN CITY—The Paden City Glass Manufacturing Company has completed a new glass factory which will employ 300 persons. The Carter Iron Works plans to add two new furnaces during the next sixty days and the Art Glass Works is building a new addition to its plant. The town is located along the Ohio River, two miles south of New Martinsburg, and is experiencing a real boom.

WHEELING—The Independent Glass Works are about ready to resume work. Since the last fire the company has purchased a building from the Wells Glass Company. Over 100 men will be employed.

WHEELING—The Ra-O Chemical Company will erect a plant here for the manufacture of tooth paste.

Wisconsin

PARK FALLS—The Flambeau Paper Company has completed plans for a mill here at Pixley Rapids, on the Flambeau River, six miles from Park Falls, Wis., to cost \$125,000. The company is developing the rapids and will build a dam.

WINSTON JUNCTION—The Zinc Contracting Company is planning to build a plant containing three roasters and six magnetic separators for the treatment of ore from this section.

Canada

HAMILTON, ONT.—The Hamilton Steel Wheel Company will erect a factory, to cost \$200,000.

LULU ISLAND, B. C.—The Shell Oil Company, whose head office is in London, England, plans the erection of a \$5,000,000 oil refinery to refine oil from western Canada and also California.

PORT COLBORNE, ONT.—The International Nickel Company is reported to have selected Port Colborne as a site for its nickel refining plant. The International Nickel Company is also contemplating the erection of a nickel refinery to treat ores from its Sudbury properties.

Metallurgical and Chemical Engineering

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Niagara Power Crisis

CANADA:

"Drink waters out of thine own cistern, and running waters out of thine own well.

"Let thy fountain be dispersed abroad, and rivers of waters in the street.

"Let them be only thine own, and not strangers' with thee."—*Proverbs*, V. 15-17.

NIAGARA FALLS, NEW YORK:

"Then I said, I am cut off."—*Lamentations*, III. 54.

"Give us water."—*Exodus*, XVII, 2.

THE SECRETARY OF WAR:

"Hear now, ye rebels; must we fetch you water out of this rock?"—*Numbers*, XX. 10.

* * * * *

"But he hanged the chief baker."—*Genesis* XL. 22.

Chemistry Should be Represented on the Tariff Commission

After thirty troublesome years of "tariff tinkering" without satisfying anybody, Congress in the last session created a Tariff Commission to put the discussion of the whole tariff problem on a sound scientific basis. To enable the commission to fulfill its mission, two things are all important. First, the commission must not be in politics. Congress has provided for this, as far as possible, by making the commission non-partisan or bi-partisan in personnel. Second, the personnel of the commission must be so chosen that it is in harmony and synchronism with the spirit of the present industrial evolution. It is left to President Wilson to solve this more difficult problem.

While the chief duty of the commission will be to gather information in a wide field, rather than to suggest legislation, yet its reports will be in fact, if not in form, recommendations of legislation. But it would be disastrous if for this reason lawyers should be thought to be especially suitable for members of the Commission. The basis of law is in precedents; lawyers have professionally a backward vision. What is needed of the members of the Tariff Commission, is a first-hand personal knowledge of the industrial problems of to-day and a forward vision of the problems of to-morrow. To be more specific, if it is true (and who does doubt it?) that chemistry will form the keynote of the industrial to-morrow of this country, then chemistry should be properly represented on the Tariff Commission. One member at least of the commission should be a real chemist, not so much a man with the fullest knowledge of chemical facts, but a man capable of interpreting chemical facts correctly, a man in sympathy with the tendencies in chemistry—a man with a chemical vision.

The directors of the two leading chemical societies of this country—the American Chemical Society and the American Electrochemical Society—have properly taken a stand in this fundamentally important matter and have recommended Mr. Ellwood Hendrick of New York to President Wilson for a place on the commission. We are glad to say that we do not know any one in the chemical fraternity better fitted by temperament and training and specific ability to do justice to this peculiarly difficult and important position than Mr. Hendrick.

Iron Ore Prices

An annual event in the iron trade is the fixing of Lake Superior iron ore prices for the season. This time the event occurred Nov. 23, prices for 1917 being established at \$1.50 above those ruling for 1916. The event might perhaps be called "the annual gamble," seeing that as a rule the last of the ore bought is not used until about eighteen months after the transaction is consummated, and pig-iron prices have a habit of moving in more than one direction in a period of such duration. More often than not pig-iron prices decline after an ore advance, or advance after an ore decline, not because the change in ore price tends to produce such a result, but because it is the nature of pig iron to decline after it has advanced, and vice versa, while it is natural for the ore interests to advance their prices when pig iron has advanced, and to reduce them when pig iron has declined.

There have been times, as in 1913, when the coke and ore producers received the lion's share of the increase the merchant furnace had secured in pig iron, while there are other times, as in the case of the iron ore shipped in 1915, when the furnaceman received large advances for pig iron without having to divide with the ore producer. Thus the sale of ore represents a gamble in the case of both parties. The establishment of an ore mine in itself is a gamble, however. While at a given time the ore trade has certain conventions, as to how much overburden it would "pay" to remove in order to uncover a given body of ore, the course of the ore market from year to year may make the venture look extremely safe or extremely hazardous. In 1915, when prices were low, the price f.o.b. mine realized for Mesabi non-Bessemer ore ran about \$1.80 per ton; in 1917 about \$3.45 will be realized. While wages and supplies have greatly increased and royalties are higher in many instances, it seems safe to estimate that the profit in 1917 will be more than a dollar a ton, or the total profit that would be counted on to be realized for a period of several years in order to return the capital invested in stripping and equipment.

The merchant furnaceman is finding that the advances he has been obtaining on pig iron are not to be all clear profit by any means. It is only a year and a half ago that merchant furnaces in the Mahoning and Shenango valleys were selling pig iron at about \$12.50 per ton, but with advances in coke, ore and various supplies, and several successive ad-

vances in wages, the prospective cost is probably all of \$20 a ton.

Altogether the iron and steel business is an uncertain one. There is no way in which it can be "played safe." If a concern establishes itself with all its raw materials, so that it is not subject to the fluctuations of the market in purchasing supplies, it is hazarding its capital against lean years in which it will be unproductive. Another concern may invest a much smaller amount of capital, confining its business to one operation, buying ore and coke, for instance, and selling pig iron or buying sheet bars and selling sheets, and in the long run it may yield a larger return on its investment. Profits in the industry are only a matter of averages. All along the line profits are now abnormally high, but the amount that may be lost when the inevitable readjustment comes is purely a matter of conjecture. Any producer who does not lay aside a large part of his present earnings against such a contingency is taking a great risk.

Expensive Slums

In our last issue we wondered what would happen to all the profits that are being made, and in the end it looked more wholesome to us that the people be engaged in making a living than that there be great profits amassed. And yet, if it is good to be gaining a living and achieving an independence, why is it not good to have both? It would seem that it should be, but we are such odd sticks that logic is about the last thing that holds good with us. There are, however, a few things that we know without any philosophizing; for instance, that the production, by industries, of a group of millionaires, on the one hand, and the establishment of slums on the other, is not a good thing for the country. Welfare is not to be measured by sales or by profits unless there is a betterment all around. There is something wrong, radically wrong, about any industry or any works that causes slums to come into being or to be maintained. Something so wrong that it is time now, this minute, to get busy over the situation.

Slums constitute a social disease, a vicious, contagious disease, and there is no use in trying to dodge responsibility for them. Suppose we were masters of a school and scarlet fever were raging among the children of the town. We might say that we do not profess to know anything about the disease, we are not physicians, our business is teaching, and we insist upon the presence of every child that can come. We should then be responsible for the spread of the disease by our neglect. Now suppose we establish an industry and, of course, need labor. Labor is scarce, and we pay the market price, which is high. We may think that we are fulfilling our duties, completely and entirely, when we hand over the pay envelopes; but a moment's consideration will demonstrate how wrong this is. In bringing up children, a parent's duty is not done when he has bought clothing and food for them. There are other duties, and the parent is blamed if he does not look after them. Again, a man does not achieve either righteousness or good repute by living simply within

the law. If he would have standing he must do more than that. But these are personal affairs, and concerning them we can, if the public gets too curious, tell it to go to the Balkans. The way we order our lives is our own business. But as soon as we engage in industry we are quasi-public characters; our success or failure affects the whole neighborhood, and our judgments and conclusions become very far-reaching. The public has an actual interest in our works. If, as the result of our establishment, slums arise, either by our acts or through our neglect, we are blamed for it, and what is more, we can't get clear of the charge. We may say it is none of the public's business, but even that will not help us. The public says it is, and it can and will proceed to tax the very innerds out of us if we continue to offend.

So, let us suppose that we are starting an industry and are engaging men. When we do this we are doing far more than making simple, short-time contracts with them. We are inviting each man to come and make his living with us, to bring his wife and family and settle down near the works. More than likely the man will not bother about his obligations to us at all; he believes, no matter what we say, that we shall lay him off whenever work grows dull, and he is not likely to worry over any agreement he may have made with us if he sees a chance to better himself. Provided always he comes from the slums he is likely to make an agreement one week and break it the next, if he can see any advantage in it. The trouble here is that he is too far down in the scale of living to be a responsible person. Under the pinch of the poverty that starves we cannot ask for good manners, and under stress of hand-to-mouth living we are not even speaking current language among laborers if we discuss contract obligations. They pay rent in advance and cash for groceries and provisions, and they have no experience in the sequence of payment after a debt is incurred. They are engaged in a low order of living in an ill-smelling, sour, ugly, cold world. They live in slums. So long as they abide in this low estate there is no such thing as a "gentlemen's agreement" to be made with them. They're down and out, and are too low-lived to be held responsible. When they get to living under better conditions we can begin to expect or hope for them to keep their agreements, but until then it is unwise to ask it of them.

Of course, workers from the slums are easily handled in one respect—they are usually so poor and want work so badly that they will do anything they are told to do. They may be a wretched lot, but they are easily driven. When they begin to do better and feel better they may organize and make all sorts of demands, many of which are neither reasonable nor just. So trouble is avoided for the moment by keeping men down to the need of to-morrow's pay. If, however, this involves the maintenance of slums, the price is too high. While the employer is making profits the state is raising weeds.

One of our excuses for slums is likely to be that the persons living there are foreigners who can't speak English, who do not know any better and who can't

learn. This is true, some of them are feeble-minded. But not all of them, by any means. And those who are not feeble-minded, by living in slums and losing heart and cultivating the gospel of hate, which is poison, are not likely to become good citizens. Children that grow up there are under a very serious handicap, and they are far more likely than other children to become a burden upon the state. They furnish the great body of criminals. Slums do not make for that wholesome discontent that seeks betterment; they make for blind hatred that seeks only to destroy such system and order as we have.

There is a scarcity of food, both in Germany and in England, and provision is now made in both countries for its more equable distribution. The shortage of food is bad, but the discipline and improved methods of distribution may, in the end, be good. It surely will provide for improvement in distribution unless a great, destructive revolution follows the war. In this country we used to provide for the needs of the hands by means of company stores until the way the poor devils were gouged became a scandal and then the thing had to stop.

Now we are beginning to feel a scarcity of food over here, and prices are soaring 'way over the tops of wages. And we do not seem to be making much of any provision against it, so far as we are informed. We say we haven't the time to bother about such things, but neither have our men the time or the opportunity or in many cases the intelligence to look up cheaper supplies.

It seems no more than fair that employers should take this matter up without any fuss or boasting and furnish employees with coal and provisions at approximately cost price, with a view to making the wages they pay more nearly a living. We need not worry about the little slum grocer who charges a hundred per cent profit on some of his wares. The reason why such merchants in slums are in such great profusion is solely because they can overcharge. On the other hand, slum conditions cut down the efficiency of wages from 20 to 50 per cent, a condition that is aggravated in a rising foodstuff market.

The slum must go. It does more harm than the profits of an industry do good. It is so poisonous, so vicious, that the social surveyors will soon have slums catalogued and accorded to the industries from which they spring. There will be no getting out of responsibility for them by moving the works out into the lonesome valleys or into the crowded cities, for the man's job and where he works is about the first thing the industrial inquisitors ask. Slums seem to have grown out of industries, and it is the industries that must destroy them. If they are not destroyed the blame and the onus will rest upon industry. This is sure to happen, because it is not at all difficult to connect slums up with their causes, and these are, usually, merely faults of omission.

It is needful for industries that they be in good standing, and they cannot maintain good standing so long as they have slum attachments.

Readers' Views and Comments

Electrolytic Recovery of Lead from Brine Leaches

To the Editor of Metallurgical & Chemical Engineering

SIR:—In your issue of Oct. 1, 1916, page 410, a paper is published by Messrs. Sims and Ralston entitled, "The Electrolytic Recovery of Lead from Brine Leaches." It seems to the writer that some of the deductions of the paper are open to criticism.

The authors state that "because of the very high current densities used the multiple connections are out of the question, owing to the immense size of busbars that would be necessary." Do they appreciate that busbars up to 26 square inches of cross section, carrying a tank current of 20,000 amp. are in use to-day in a prominent copper precipitation plant? The tank current for multiple connection at a cathode current density of 40 amp. per square foot of surface, as proposed, figures out at only 14,400 amp., an amount of current not difficult to handle. Of course, the capital outlay for such busbars is heavy but the proposition is unsuited for organizations with small capital available and the others would be able to stand it.

I fail to see why such high current densities are emphasized, 40 to 60 amp. per square foot. In Fig. 3 of the article, fixed current density curves showing the relation between cathode efficiency and concentration of lead in the electrolyte are given. It will be seen that the curve for 20 amp. per square foot gives about the best average result for all variations of strength of lead solution. Its advantage becomes more marked as the solution becomes weaker. Yet the plan for a 10-ton operating plant calls for a 40-amp. density.

This brings me to another point. According to a comparative table given, the highest yield of lead per kilowatt-hour, 16.1 lb., comes at the neglected current density of 20 amp., and using a multiple system. Yet the scheme for an operating plant is laid out on the series system and with the idea of working toward a possible yield of only 5.9 lb. per kilowatt-hour. It would seem as though more attention might be focused on a 20-amp. density, a multiple system, and the figure of 16.1 lb. yield per kilowatt-hour, particularly as a new process is being considered which as outlined will work at the narrow margin of profit of only \$22 per ton of product.

The plan for a commercial tank calls for a screw conveyor in the bottom to push the loose sponge deposit out into a collector. Sponge deposit in electrolytic precipitation plants is the bane of existence to the operators. Working for a coherent deposit would seem more logical and this could doubtless be readily obtained at a lower current density. The trend of precipitation plants as used for copper and zinc is toward large aggregate units, say 100 to 500 tanks. The high equivalent of lead, about 3.26 that of copper and 3.17 that of zinc, enables the lead plant to be much more compact for equal tonnage. As it is safe to say that the most favorable results with lead will only be obtained when working on a large scale, it will be seen that even with the advantage just mentioned we run into a large number of tanks, perhaps 100 or more. What I am getting at is that mechanical difficulties are to be anticipated in attempting to keep so many screw conveyors properly at work during the greater part of the time and in large deep tanks where they are inaccessible. The screw conveyors would seem to be a weak point in the process, not to mention the air agitation, long since abandoned for similar work.

It would appear that much promise would lie in experiments along the lines of moderate current density; coherent deposits, to be obtained naturally or by the use of suitable addition agents; efficient circulation by a properly directed flow; tanks clear of all mechanical apparatus, *i.e.*, as simple and fool-proof as possible; partial rather than complete electrolysis of the lead solution; a multiple system in preference to a series; a better yield per kilowatt-hour, which would come naturally from some of the preceding factors. The use of iron anodes appears excellent both in theory and practice and would doubtless go far toward solving what is usually one of the biggest problems in such processes.

Messrs. Sims and Ralston are doing pioneer work and personally the writer is confident that a future will develop for electrolytic precipitation of lead, just as zinc is rapidly progressing at present and occupying the attention of metallurgists as copper began to do several years ago.

Lexington, Mass.

MAURICE R. THOMPSON.

* * *

To the Editor of Metallurgical & Chemical Engineering

SIR:—We are grateful for the discussion by Mr. Maurice R. Thompson of our paper, which was presented at the September meeting of the American Electrochemical Society and which was published in the October 1 issue of METALLURGICAL AND CHEMICAL ENGINEERING, and thank Mr. Thompson for his helpful criticism of our work. The questions raised by him show that it would have been well for us to have explained more fully our ideas as to the proper design of a commercial cell for this kind of work.

We are fully aware of the advantages of the multiple form of connections as suggested by Mr. Thompson, but conditions other than those ordinarily met with in the electrolytic refining or hydroelectric extraction of copper and zinc, have to be considered. Our work at the Salt Lake station of the Bureau of Mines has to do with developing ways and means of treating low-grade and complex ores. Among the pressing problems are those of the treatment of small low-grade deposits of lead carbonate which are of a physical character such as to defy mechanical concentration. The brine leaching process outlined would allow of the extraction of the lead in a very simple and inexpensive leaching plant, but when it comes to the electrolytic precipitation of this lead we are confronted by the fact that generators of high ampere capacity and low voltage cost 200 to 300 per cent more than generators of more normal voltage, and lower amperes. In addition to the cost of generators there is the investment in large bus bars which, although allowing better efficiency, would make the installation costs prohibitive for a small plant designed for the treatment of a small deposit of ore. Where a very large deposit of ore is to be treated, a larger plant could be designed in which advantage could be taken of some of these rather expensive ways of improving electrical efficiency. High-efficiency electrolytic plants are usually not classed among low first-cost metallurgical ventures.

Then, too, it is to be remembered that in this particular work so much lead is obtained per kilowatt-hour of energy expended that the cost of power is very small compared to the other items. We would also call attention to the fact that this cost, even at the sacrifice of some efficiency, is only one-fourth of the cost of the iron

used or anodes. Under these circumstances the economy of power should not be the prime consideration in the design of the electrolytic plant for lead work, while it is all-important in copper and zinc work. A cheap high-voltage, low-amperage generator, with small bus bars and series connections, permits of the use of a cell that covers only a very small floor space. This means that a small and comparatively inexpensive precipitation plant can be built for the recovery of lead from brine leaches which we feel is the condition that must be met when treating such ores as are being studied in our work. The use of an electrolytic equipment costing twice or three times as much as the proposed plant, would cut the power costs in half and save \$1.70 on every ton of lead, or 17 cents on every ton of ore, as far as operating costs are concerned. This 17 cents might pay interest on the extra investment if the investment were justified by the size of the deposit being treated. At the best it would mean a small saving.

Taking up the question of sponge metal and the method of removing it from the tanks and handling it, we agree with Mr. Thompson that it would be much better to have a process giving solid deposits instead of sponge. However, in all of the voluminous literature on the deposition of lead we know of no process which has obtained solid reguline deposits from chloride solutions. Our excellent leaching agent unfortunately is a bad solution for electrolytic work. The only improvement over the production of true sponge which we could suggest was to use a slight acidity in the brine, under which, as stated, the sponge had the appearance of heavy crystals which built up and subsequently fell off of the cathode plates.

The disadvantages of a screw conveyor buried deep in the bottom of a cell are acknowledged by us but they are not what could be called serious—merely inconvenient. But if the solution does not allow of the formation of reguline deposits and we find that a semi-crystalline sponge can be formed with ease and handled with comparative ease, the question came up, "What is the use of trying to remedy something which is really hardly a disadvantage?" As stated in the paper we decided to seize the bull by the horns and make sponge metal, and thereby open up the use of a range of electrical conditions in the electrolytic work which was otherwise not possible.

Mr. Thompson also objects to the air stirring but with the high current densities which seemed allowable in this case, we found that no amount of natural circulation was sufficient. It is to be remembered that we are dealing with a highly conductive brine but that it is very dilute as far as lead is concerned, and intense stirring is necessary. Air stirring is one of the most efficient ways of turning over a solution.

We believe that this explains why all of the apparently objectionable things were done in this work. Mr. Thompson's discussion, however, is timely and seems to emphasize the fact that the problems involved in a hydro-electrometallurgy of lead are different from those which ordinarily confront the electrometallurgist.

Salt Lake City, Utah.

O. C. RALSTON.

Facts About Potash

To the Editor of Metallurgical & Chemical Engineering

SIR:—In your issue of Nov. 1, 1916, page 508, is an article on the "Development of Our Potash Industry," by F. M. de Beers, in which the following statement appears: "A brief review here of what we bought on the average per year from Germany may not be out of place. In round figures the following list shows approximately what we imported each year:

	Tons
Potassium muriate (80 per cent).....	250,000
Potassium sulphate (90 per cent).....	50,000
Manure salts (20-38 per cent).....	200,000
Kainit (12-15 per cent).....	500,000
Total	1,000,000

"Figuring all the potash as K₂O or potassium oxide would show about 360,000 tons of the oxide in the above importation. Our yearly supply of German potash cost us about \$20,000,000 before the war."

This statement is false in every particular. The real imports of actual potash (K₂O) from Germany for the past ten years, including all used in agriculture and in chemical industries, are as follows:

Year	Short tons K ₂ O
1904	117,444
1905	129,084
1906	155,974
1907	144,351
1908	136,057
1909	173,220
1910	279,780
1911	274,446
1912	253,678
1913	267,970
Average, ten years	193,200

It will be seen that the average yearly imports were only 53.6 per cent of what Mr. de Beers states they were, and the maximum in any year were only 77.8 per cent of his alleged average of 360,000 tons of K₂O. His statement of cost, \$20,000,000, is about 50 per cent above the actual cost c.i.f. American ports.

No industry keeps more accurate production statistics, or distributes them more willingly than the potash industry—they are available to anyone who asks for them. For the past seven years "potash baiting" has been a favorite pastime of sensationalists from the highest officials down to the humblest penny-a-liner. Heretofore this has been a source of innocent merriment to those connected with the potash industry. But it is hardly right to permit such misleading statements to stand without correction.

German Kali Works,
New York City

H. A. HUSTON.

To the Editor of Metallurgical & Chemical Engineering

SIR:—Answering Dr. Huston's criticism, I must apologize if I offended the German Kali Works, as there was certainly no intention to do any harm as might appear from Dr. Huston's agitation. In the first place, I am pleased to note that no specific fault was found with the table itself which is, I would therefore understand, an average of our importations of recent years (1911-12-13). These are the years that interest us most as representing more nearly our present needs. In the second place this paper was not intended as a review of what we imported. The title indicates that I prepared the same by request and on the last day before I left Chicago to present it, I added the clause about our importation, thinking this would interest my audience, although I realized this might not be entirely correct, but would be sufficiently so for the purpose intended. The only ready reference I had this last day was a set of year books published by the *American Fertilizer*.

It is evident that some of the percentages were a little wrong or that the average K₂O content was lower than I figured, but no harm was intended and I fail to see where any was done. If the actual K₂O imported was only 75 per cent of what I read as being approximate figures, it is reasonable to suppose that by this

time, but for the war, my estimate would be nearly correct.

The value is proportionally wrong also, but whether the amount is \$16,000,000 or \$20,000,000 has little bearing on the subject matter of my paper, which was intended to show what *we are doing* and what we can hope for.

I trust Dr. Huston does not imagine that I would presume to write a paper on the German potash industry or any of its branches. His words are rather harsh and because of this they make me wonder if anyone is afraid our little infant industry might develop too rapidly.

I tried in my paper to make it clear that only a few of our present sources can be commercially successful during normal times and that our next year's production is only possible because of the very high prices at present. It is certainly fortunate for me that Dr. Huston did not begin his table back about 1890, for that would make my rough approximations look still worse.

Chicago, Ill.

F. M. DE BEERS.

Guayule and Industrial Preparedness

To the Editor of Metallurgical & Chemical Engineering

SIR:—I have read Mr. King's article on Guayule and Industrial Preparedness with a great deal of interest and I wish to say that this is a most important problem for our country. Three years of war conditions have demonstrated that we are impotent so far as rubber supplies are concerned, and that a foreign power can with one stroke cut us off from a raw material far more important than coal tar dyes.

Anything which will draw attention to the development of American controlled raw rubber will serve to make this country more secure in its liberty. It may in fact be possible to convert chicle into a rubber-like gum by some process of chemistry, and then we might draw on the chicle forests of Central America.

As early as 1912, the German chemists had perfected a method for producing synthetic rubber at \$3 per pound, and we are now reliably informed that they have brought their process to a point where synthetic rubber can be produced at about \$1 per pound. This price is based on the cost of raw materials before the war.

At this moment their rubber is costing them more than this, but the fact remains that under normal conditions the German chemical factories will be able to produce synthetic rubber at about \$1 per pound. Have any of our American chemical manufacturers considered the possibilities of this new movement?

FREDERIC DANNERTH.

Rubber Trade Laboratories
Newark, N. J.

Southern Barytes Mining

To the Editor of Metallurgical & Chemical Engineering

SIR:—Barytes (to use the trade term) is being produced on an immense scale in the Southern States at the present time, due to the German supply being cut off, and an increasing demand from lithophone manufacturers, chemical works and a great variety of other manufacturing plants.

In the Cartersville, Ga., district, the ore occurs as large and small lumps, in loose and extensive deposits, mixed with clay. It is mined by steam shovels, and put through log washers to float away the clay and yield a white product. Some of the washers are equipped with jigs to clean the small sizes. The amount of material available is very large. Barytes in such de-

posits is pretty sure to be free from sulphides which are present in the mineral from some underground mines. There are many known vein deposits of barytes, it is probable that deposits of this class result from the weathering of rocks containing barytes veins.

Similar deposits exist elsewhere in Tennessee, Georgia, Alabama and Virginia, but they are less developed, and in some cases at least the mineral is contaminated with other minerals, usually limonite.

In the Western North Carolina district, which was formerly an important producer, the mineral is raised from vein deposits. Large ore shoots have been worked to considerable depth. In some cases these shoots are as thick as 16 feet of the pure mineral. Below the zone of oxidation, which is quite deep, the barytes has a bluish color due to the dissemination of very fine galena (with no silver). The walls are generally both granite with slate near, or one granite and one slate wall. One possible explanation of the origin is, that the feldspars in the granite contain barium, and the extensive decomposition of the granite furnished soluble barium compounds, while the oxidation of the pyrite in the slates furnished ferrous sulphate. A fissure vein forming a natural outlet for these waters, drew the waters from each side, and eventually closed up with the precipitate.

Barytes of high purity (compared with most other raw mineral products) is put on the market at low prices, according to United States Geological Survey, as follows:

State	1912		1913		1914	
	Tons	Value per Ton	Tons	Value per Ton	Tons	Value per Ton
Missouri	24,530	4.77	31,131	3.78	33,317	3.37
Tennessee and Kentucky	3,718	2.34	2,098	1.70	8,932	1.61
Other States	9,230	2.99	12,069	2.91	9,298	2.91

It is probable that these figures do not include the cost of transportation to the railroads, and loading, and possibly are intended to cover the actual cost of production only at the mine.

Occasionally deposits of barytes are heard of in the Northern States and Canada. Conditions for production of high quality goods are more favorable in the Southern States, however. The glacial deposits have hidden many of the mineral resources of the Northern States, and also the depth of oxidation is in general slight.

In the Southern States, the vein barytes deposits have been found inclosed in decomposed and oxidized formations to depths of several hundred feet, but still in place, and at other points the original formation has been totally obliterated but with the product otherwise undisturbed or transported, and not covered up with other material. As explained before, barytes from oxidized zones is better quality, due to the oxidation of sulphides and leaching of soluble mineral contaminations.

Due to the cessation of imports, the mining of barytes is at present reasonably profitable, but with the resumption of imports coming in as ballast at low rates, it is feared that the industry will be reduced to its former unsatisfactory condition.

We venture to assert that there are large possibilities ahead for the manufacturers of barium chemicals and products. The raw material exists in large quantities and can always be bought at reasonable prices.

Box 843, Asheville, N. C.

SANDY BOTTOM BARYTES MINES,

Coming Meetings and Events

American Society of Mechanical Engineers, New York, Dec. 5-8.

Joint meeting of New York sections American Chemical Society, Society of Chemical Industry, and American Electrochemical Society, New York, Dec. 8.

American Association for the Advancement of Science meets with American Chemical Society and also with the four national engineering societies, represented at the Engineering Societies Building, New York, Christmas week, 1916.

American Institute of Chemical Engineers, New York, Jan. 10-13, 1917.

The Niagara Power Crisis

"The help that should within be sought,
"Scorn from without to borrow—

"If ill at others' hands ye bear,
"The cure is in Your own." *Ourselves Alone*,
JOHN O'HAGAN.

The Cassandras who for years have been making gloomy forecasts of a power famine in Niagara Falls are now saying "I told you so." Here is the situation at present:

Canada, thanks to the activities of the Ontario Hydro-Electric Commission, has been taking more and more electric power from the Niagara River, and now finds herself running short. Since Canada made a treaty with the United States about the diversion of water from Niagara Falls she has encouraged the development of hydroelectric power to the fullest extent, and this power has hitherto found its larger market in the United States. The Canadians, however, with admirable foresight, have kept their own ultimate interests in view, and consequently the power companies on the Canadian side of the river have revocable permits for exporting power. Thus these power companies can be forced to supply power to Canadian users when they want it.

One result of this arrangement in the past has been the steadily increasing migration of United States electrochemical industries to Canada. This works automatically. When, owing to the relative scarcity of power on the United States side of the river, an electrochemical industry found difficulty in having its requirements met, it turned to Canada, was received with open arms and got power on most advantageous terms. Then Canada calmly sliced off a block of power hitherto exported to the United States. The difficulty of obtaining power in the United States then remained as before, and the process was repeated.

Within the last few weeks the Ontario Hydro-Electric Commission has made a big demand on the Canadian Niagara Power Company for more power. When it was pointed out to the Hydro that this could not be done without seriously embarrassing some of the power company's United States customers the Hydro replied in effect: "We don't care a cent for your United States customers."

Now one of these customers is the Acheson Graphite Company, which supplies several important munitions works in England. The Englishmen, in great alarm, on hearing the effect of Canada's demands, promptly sent a protest through the British Minister of Munitions to the Imperial Munition Board in Ottawa asking mercy of the Ontario Hydro-Electric Commission. But the Hydro was as the deaf adder who stoppeth her ears. Moreover, the Canadian Government has hardened its heart and will not let the power go if its own people want it.

There is no question as to the logical attitude of the Canadians. According to the treaty with Canada the United States is entitled to take 20,000 cu. ft. of water per second, and it actually takes 15,600 cu. ft. Some years ago, when it was desired to generate more power at Niagara Falls on the United States side of the river, this was prevented by the Burton bill, which forbade the use of the remaining 4400 cu. ft. of water. At the end of three years the prohibition of the Burton bill lapsed, but additional water could only be used by permission of the Secretary of War. At the present time the power companies in Niagara Falls, N. Y., have sufficient equipment to utilize much more than 15,600 cu. ft., but for some occult reason Secretary Baker will not grant a permit. Therefore, the Canadians say in effect: "If you want more power why don't you go ahead and use it. If you cannot get your government to allow you to use water to which you have a perfect right, why should we deprive our people of power to satisfy your demands?"

As always happens in affairs of this sort, the real sufferers are the innocent bystanders, the people of the United States. That is one of the advantages of democracy. No one imagines for a moment that the shortage of power caused by Secretary Baker's attitude is going to ruin the power companies; probably the effect will be just the opposite; nor will it ruin any of the power companies' customers, although the cutting off of their power supply will undoubtedly diminish their business to a serious extent. The real sufferers will be those who depend upon the Niagara Falls products. The user of all kinds of steel into every ton of which Niagara Falls ferrosilicon enters as a necessary constituent, the inhabitants of all the cities throughout the country depending on Niagara Falls chlorine for purifying their water supply, the machine shops absolutely dependent on Niagara Falls abrasives, the automobile manufacturers, the gold miners, and so on. The unfortunate "ultimate consumer" will soon find that for some mysterious reason the cost of hundreds of articles which he uses every day of his life has increased.

At its meeting in New York, Nov. 24, the Board of Directors of the American Electrochemical Society took up the matter of the Niagara Falls power crisis on the recommendation of the society's committee on public relations, and directed the president to send the following communication to the Secretary of War:

To the Secretary of War, Washington, D. C.

Sir:—The Committee on Public Relations consisting of the President and Past Presidents of the American Electrochemical Society reports to the Board of Directors that owing to the large demand for power in Canada a considerable block of power now imported to this country will be cut off. The shortage of power in the United States caused by this Canadian demand will have a serious effect on our electrochemical industries.

Protests to the Canadian Government by the electrochemical industries of the United States are met by the reply that the Canadian Government must consider the interests of its own people first. It is therefore apparent that in order to assist our electrochemical industries in this emergency our government must be appealed to. The Committee on Public Relations, therefore, recommends that the Board of Directors of the American Electrochemical Society should communicate with you urging you to permit the temporary diversion of the 4400 cubic feet of Niagara River water allowed by our treaty with Canada, until such time as Congress can take action in the matter.

After careful consideration the Board finds that in view of the serious crisis threatening the electrochemical industries of Niagara Falls, N. Y., it can strongly endorse the solution of the problem proposed by the Committee on Public Relations.

In endorsing the recommendation of the Committee the Board does not desire to offer any advice as to the ultimate disposal of the 4400 cubic feet of water allowed to the United States by its treaty with Canada; but simply to

emphasize the fact that the threatened power shortage is a serious menace to the welfare of our country since this is so largely dependent on the products of electrochemistry.

As an example showing how the power shortage will affect an important industry the Board respectfully calls your attention to the inclosed letter. The facts set forth are the more interesting in that the products of this factory are an absolute necessity to many other electrochemical industries. Thus, these are not only affected directly by the power shortage, but are indirectly embarrassed through their inability to obtain a sufficient supply of material necessary for their manufacture.

This is but a single example out of many which could be given, and the Board therefore begs to offer you its services in supplying any further information you desire as to the need of our electrochemical industries. Yours respectfully,

Francis A. J. FitzGerald,

President, American Electrochemical Society.

* * *

Niagara Falls, N. Y., U. S. A.

Nov. 23, 1916.

Mr. F. A. J. FitzGerald,

Pres. Am. Electrochemical Society,
Niagara Falls, N. Y.

Dear Mr. FitzGerald:—So many electrochemical industries are being affected by the present shortage of power, that it seems to us this matter should be taken up by the Public Relations Committee of the American Electrochemical Society, and by them presented to our Secretary of War in order that he may see the seriousness of the situation. In order to give you and the Committee some information on this subject, we will review as briefly as possible our own experience.

We have always tried to keep our producing capacity very greatly in excess of our actual output, so as to be ready to take on new business in any amount and make prompt deliveries. During the past few years we have had equipment capable of manufacturing about twice as much graphite as we have actually made. When business began to increase, due to the war-stimulated demand, we put in another large electric furnace unit so as to keep ahead of our customers' requirements. In past years the limiting feature of our manufacture has always been our producing units, as there was quite a surplus of power which we could use when needed. During the past year, however, the demand for power in the United States has increased, and the Ontario Hydro Electric Commission has commandeered large blocks of power which were formerly exported to the United States. These two facts have produced a condition where the limiting feature in our manufacture is the matter of power instead of a question of equipment as formerly. At the present time we are equipped to take approximately 10,000 e.h.p. 24 hour power, but owing to the power shortage we are able to get only 53 per cent of our requirements, which means that we are now operating at about 53 per cent of our capacity.

We have recently been informed that the Ontario Hydro Electric Commission have made a further demand upon the Canadian Niagara Power Company for 15,000 e.h.p. to be delivered Dec. 1, and if the Power Company finds it necessary to deliver this amount of power to the Hydro Electric Commission on that date, we will be cut down to 30 per cent of our requirements. In other words, we will then be forced to run at only 30 per cent of our capacity.

Recently some of our English customers who are manufacturing munitions for the British Government, sent a protest through the Minister of Munitions in England to the Imperial Munitions Board at Ottawa, asking that the Ontario Hydro Electric Commission be as lenient as possible with the Canadian Niagara Power Company, as any further withdrawals of power would limit our ability to supply electrodes. We also wrote to the Provincial Secretary of Ontario, stating that withdrawals of power were curtailing the output of some of the British munition factories, due to our inability to supply them with electrodes, and asking that the matter be taken up with the Ontario Hydro Electric Commission. To all of these protests, however, the Hydro Electric Commission have been deaf, and have insisted upon having more power delivered to them, and, as stated above, have demanded an additional 15,000 e.h.p. on Dec. 1. While the information we gave the Provincial Secretary is absolutely true, yet it must be remembered that a very large percentage of our output is sold in the United States. At the present time, probably 75 per cent of our output is sold to manufacturers in the United States, who are absolutely dependent upon us for their supplies.

As you probably know, we are now building near Buffalo a new plant at a cost of approximately \$750,000, to take power from the steam generating station of the Buf-

falo General Electric Company. This new plant will give us a very large capacity, and we hope with its aid to be able to take care of our business very comfortably. However, we will naturally depend upon our Niagara Falls Plant for a considerable amount of output, and if the power situation here does not improve, we can only operate our Niagara Falls plant at 30 per cent of its capacity. The Niagara Falls Power Company have a permit to take sufficient water above their regular allotment to operate two extra machines, which generate about 12,500 hp.

While we are not familiar with the exact terms of this permit, we understand that the Niagara Falls Power Company was formerly allowed to use this extra water from 7 a. m. to 6:30 p. m., but that this permit was to expire when the first turbine of the Buffalo General Electric Company was put in service. We also understand that recently the Secretary of War has modified the terms of this permit so as to allow the Niagara Falls Power Company to use these two extra wheels during the peak period of the day, and solely for the benefit of the Buffalo load. It seems to us, therefore, that under the stress of present conditions, the War Department might at least extend the permit to use the additional water for these two extra wheels to 24 hours per day and allow them to take this water indefinitely or until Congress legislates upon this subject. It can easily be shown that the manufacturers at Niagara Falls are of as great value to the country as those in Buffalo, and some with whom we are familiar probably manufacture articles of more value and of greater necessity to firms all over the United States than anything manufactured in Buffalo. We therefore feel that this matter should be presented to the Secretary of War, who we feel sure will see the reasonableness of our position. Not only do we feel that we are as much entitled to relief under the present conditions as those elsewhere, but we cannot see that the withholding of this permit during the night is of any advantage to the Falls or to navigation on the Great Lakes, and we also feel that if the War Department can see its way clear to allow this water to be used during the summer and fall of 1916, they ought to be willing to have it used in the winter and spring of 1917. The reason we urge the extension of this permit is that it seems to be the only possibly chance for immediate relief.

The power situation here divides itself into two phases. First, there is the question of greater permanent development, which we earnestly hope will be permitted in the near future. Second, there is the question of immediate action to give the existing power companies all the water they can use at once, keeping, of course, within the treaty limits. As to the first phase, we feel that public opinion and the pressing necessities of the situation will bring favorable action from Congress. As to the second phase, we believe that the only hope for relief will be a decision of the Secretary of War, and we further believe he would not be establishing any vested right nor taking any chance in allowing more power to be generated during the interval from the present date until Congress sees fit to act. If there is any question about this, we feel sure that the Secretary will give us the benefit of the doubt.

We are, of course, interested in the future development of more power at Niagara Falls, and we earnestly trust this will be brought about. We are, however, intensely interested in getting immediate relief, for we will soon be running at only 30 per cent of our capacity, because the Canadian authorities are looking after the interests of their manufacturers.

Trusting the Committee will take this matter up and be successful in getting immediate action by our Secretary of War, we are, Yours very truly,

Acheson Graphite Company,

Acheson Smith, Vice-Prest. and Gen'l Mgr.

In Niagara Falls the electrochemical manufacturers are awaiting anxiously the action of Secretary Baker. Every effort on their part to influence him has so far been useless or worse, for apparently our learned Secretary puts them in the same class as George Washington and the soldiers of Valley Forge. In his most recent edict in the power crisis he has permitted some relief to Buffalo for lighting and power service, but expressly stipulated that not 1 kw.-hr. of energy thus doled out should go to the electrochemical manufacturers.

The situation of the electrochemical manufacturers in facing their angry customers all over the country is bad now, but they tremble to think of what it will be when on Dec. 1 Canada makes its next cut in power export.

Non-Ferrous Metal Market

Nov. 25—A stronger tone is evident in all the metals. Copper, tin, spelter, antimony and silver have all made advances during the past two weeks, and while the Trust price of lead remains unchanged, independents are asking higher prices. Conservative interests are issuing warnings that if prices of commodities continue to advance as they have been, a crash will come sooner than expected, and the higher we go the greater will be the fall.

Copper.—The difficulty of finding sellers has caused further advances in copper prices. On Nov. 13, 32.50 was asked for electrolytic and lake, while on the 14th it rose to 33.00, on the 17th 33.50, and on the 20th 34.00 cents was asked, which price prevails at present. First quarter of 1917 is offered at 33.50 and second quarter at 32.50, with the last half offered at 30.00 cents cash New York. Exports up to Nov. 24 were 14,979 long tons.

Tin.—Straits tin was quoted on Nov. 13 at 43.87½ cents asked. On the 14th it rose to 44.37½, on the 15th to 45.00, and on the 23rd 45.50 cents was asked. A serious situation in spot tin is liable to develop if the granting of permits is not facilitated. The foreign market seems to be influenced by reports of heavy business and big demand in this country, and the London market has been steadily advancing. Very few offers for future delivery Straits are being made. Arrivals up to Nov. 21 were only 1250 tons, but there is reported by the American Metal Market over 2000 tons still due this month.

Lead.—No advance in the price of lead has been made by the Trust, and its official price is still 7.00 cents New York for spot metal. Independents are asking 7.25 for spot at New York, and the opinion seems to prevail that a further advance by both Trust and independents may be looked for. Exports up to Nov. 24 were 1327 tons.

Spelter.—Spelter is in a much stronger position. On Nov. 13 it was quoted at 11.42½ cents asked, New York, on the 17th it had risen to 12.30, and on the 23rd sellers were asking 12.92½ cents. Brass mills have been heavy buyers, and futures have been in good demand, forcing prices up.

Other Metals.—*Antimony* is active again, and has risen from 13.00 cents on Nov. 13 to 14.50 on the 23rd. No quotations are available on American antimony, the above being for Chinese and Japanese. *Aluminium* continues the same, at 64.00 cents bid and 66.00 asked. *Metallic magnesium* is offered at \$3.50 per pound, *electrolytic nickel* at 50.00 cents, *cadmium* at \$1.50, *quick-silver* at \$80.00 per flask, *platinum* at \$105 per ounce, *cobalt* at \$1.50 per pound, and *tungsten ore* at \$16 to \$17 per unit. *Silver* has risen from 71¼ on the 13th to 73¼ on the 23rd.

The Iron and Steel Market

Announcement was made on Nov. 23 that sales of Lake Superior iron ore had fixed prices for the season of 1917 at an advance of \$1.50 over prices ruling for 1916, or at \$5.95 for old range Bessemer, \$5.20 for old range non-Bessemer, \$5.70 for Mesabi Bessemer and \$5.05 for Mesabi non-Bessemer, on Lake Erie dock. The base ore contains 55 units in the case of Bessemer and 51½ units in the case of non-Bessemer. Settlements are made on a unit scale, with some divergences by way of special premiums and penalties on ores running far from the base, phosphorus content in the case of Bessemer ores, etc. The 1914 schedule of

prices was the lowest since 1905. In 1915, through some accident, Mesabi ore was 5 cents lower, and this divergence was made up for 1916 by old range ores being advanced 70 cents and Mesabi ores by 75 cents, so that the 1917 schedule represents a total advance from 1914 of \$2.20 per ton.

Fifty cents of the advance for 1917 goes to the lake vessels, as the carrying rate was recently established, by large chartering for the season, at \$1 net to the vessel, against 50 cents as the standard rate in the season just closed. There is in addition an unloading charge of 10 cents paid by the shipper. The loading charge at upper lake ports is absorbed in the regular rail freight from mine to dock.

The major portion of the prospective pig-iron production of the merchant furnaces in the first half of 1917 was sold recently at substantially the going market for this year's deliveries, while sales for the second half of next year did not begin until large advances had occurred. Basic iron was sold freely for the first half at about \$18, valley furnaces, but the first important sales for second half occurred at \$24, and still higher prices have since been paid. The merchant furnaces can therefore face the stiffest advance that has occurred in iron ore since the advance from 1899 to 1900 with much more equanimity than various smaller advances that have occurred meanwhile, frequently at a time when the pig-iron market was near the end of an advancing movement.

On Nov. 21 the United States Steel Corporation announced a general advance in wages, on the part of its subsidiary companies, amounting to about 10 per cent, and to become effective Dec. 15. An advance by Jan. 1 was more or less generally expected, but the early announcement occasioned some surprise. No question arose as to the action of independents. As labor conditions are aligned advances made in any quarter most perforce be general. The present advance is the third of the year, the others having become effective Feb. 1 and May 1. The first occurred after various labor troubles had broken out, particularly in the Youngstown district, though not affecting immediately the Steel Corporation's plants in that district, while the second advance occurred when trouble was evidently brewing. The present advance does not seem to have been preceded by a similar degree of unrest, but is obviously in keeping with the continued increase in the cost of living. No special labor shortage is felt at this time, as outdoor construction work of various descriptions is necessarily curtailed.

In iron and steel operations the most serious menace has been with respect to transportation. The acute scarcity of cars at coal mines, which developed weeks ago and resulted in some steel works buying spot coal at from three to four times the price at which coal was due them on contract, was expected to be relieved by the closing of lake navigation, and relief was also expected as to cars for coke, and the more serious apprehensions were felt as to supplies of flats and gondolas, and to a less extent of box cars, for the shipment of finished steel products from mills. Early in November conditions were growing more serious, and considerable quantities of finished steel were piled, though not enough to interfere seriously with production. The establishment of various embargoes by the railroads, and their strenuous efforts both to move cars more expeditiously and to induce shippers and consignees to act with more expedition, aided by a continuance of mild weather, have slightly relieved the situation, which is nevertheless tense because the first really bad winter weather always ties up the

railroads more or less and they have been in no condition to stand any extra strain. It is regarded as distinctly possible that the production of iron and steel will be materially reduced this winter on account of inadequate transportation facilities.

As to steel prices it is difficult to make a comprehensive statement. Almost constantly mills are advancing prices of one finished commodity or another, and the rate of advance is quite rapid. At the same time steel prices are being more and more regarded as "nominal," in that while a mill may have a fixed price it is a question to whom, or in what quantity, or for what purpose, steel will be sold. The mills are endeavoring to pick and choose the business they will accept, but whether this represents a precaution tending to make the situation safer, or discloses a belief that the condition is unsafe, might well be a subject for debate. One comprehensive statement can be made, that using a weighted average of the various finished steel products, excepting standard steel rails, the advance from the low point of December, 1914, to this date is almost precisely three times the amount required to bring prices up to the top level of 1907, the highest level between 1902 and 1916. The comparison is of prices "for delivery at mill convenience" and not of the premium prices paid for many commodities for early delivery.

On Nov. 15 announcement was made of an advance of \$5 a ton in standard steel rails to \$38 for Bessemer and \$40 for open-hearth, f.o.b. mill. The railroads were given no advance notice, and indeed for several weeks prior to the announcement of the advance the rail mills were somewhat indisposed to entertain inquiries. A rather curious incident in this period was the mailing of an order for 25,000 tons of rails, without previous negotiation. In the case of the advance of \$5 a ton effective on May 1 last several weeks' notice was given, railroads being permitted to place orders for 1917 delivery, for replacement purposes, at the old prices, \$28 for Bessemer and \$30 for open-hearth. It was in February, 1901, that the \$28 price had been established, there being no change in 15 years except that when open-hearth rails became a regular market commodity they were placed at \$2 a ton above Bessemer.

Pig iron prices have been advancing very sharply, at an average rate of about 20 cents per business day. Even at a given moment prices are not clearly defined, there being divergences as to tonnages and deliveries, and frequently in a given market a price has advanced \$2 a ton practically over night, with no sales of moment occurring at intermediate prices. Using a weighted average, pig iron at this writing in the United States stands at about \$26, f.o.b. furnace, against about \$12.50 at the low level in the first half of last year.

The Western Metallurgical Field

Flotation

Some Devices Used to Regulate the Flow of Oil in the Flotation Process.—At the Inspiration Mill at Miami, Ariz., a bucket elevator with variable speed is used. At the mill of the Miami Copper Co., Miami, Ariz., the oil is contained in a barrel on a scale. The oil flows into a tank in which a float is so arranged as to keep the level of the oil constant. The outflow of the oil is taken care of by a regulated valve.

The appliance used at the mill of the Chino Copper Co., Hurley, New Mexico, consists of a tank, which is fed by as many faucets as there are oils used to make up the mixture used in flotation. Metal discs rotate vertically in this tank. They are immersed to a certain

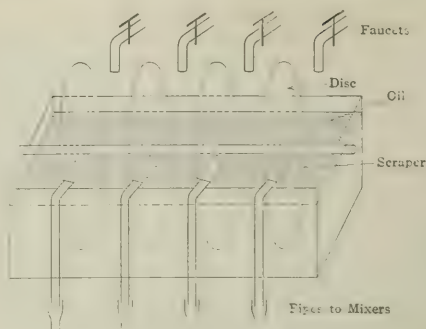


FIG. 1—PRACTICE AT CHINA MILL

depth in the oil. The number of discs depends on the number of mixers to be supplied. On one side each of the discs is a metal scraper of certain width, which scrapes off the oil from the disc. The oil scraped off flows through suitable pipes into pipes leading to the mixers. (See Fig. 1.)

The apparatus used at the new mill of the Vindicator consists of a tank holding the oil, in which rotates a

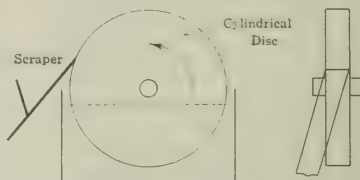


FIG. 2—PRACTICE AT VINDICATOR MILL

cylindrical disc. As at the Chino, this disc is partly immersed in the oil. The scraper in this instance comes in contact with the cylindrical part of the disc, thus scraping off the required amount of oil. The number of discs used will depend on the number of mills to which oil has to be added for mixing. (See Fig. 2.)

"Air Flotation."—Mr. William H. North of the Sutton, Steele & Steele Mining, Milling & Machinery Co. of Denver, Col., is visiting Joplin with the view of introducing a new dry process of ore concentration. Those other sections of the zinc milling districts will be visited where water supply is scarce. Mr. North's process, for which the term "air flotation process" has been coined, not only eliminates the use of water, but it is claimed to make a 2 per cent greater recovery than the water-cleaning concentration process used almost exclusively throughout the district.

In a general way, the process requires an ordinary rock crusher to prepare the ore-run dirt for separation. However, rolls giving special mesh are part of the specifications of the new method. The mesh obtained by the rolls range from 0.02 in. to $\frac{1}{8}$ in. A fan is used in the separation process, the force of the fan separating the waste from the free ore, permitting the cleaned ore to fall into a special bin, while the gangue goes to another bin.

Company Reports

The annual report of the *Tonopah Mining Company*, ending with February, 1916, gives the following data of interest: Few changes have been made in the mining methods. Ninety-six thousand seven hundred and thirty-five dry tons of ore, averaging \$14.41 per ton, and

39,462 dry tons of dump ore, averaging \$11.09 per ton, were shipped to the mill. The total mining cost per ton was \$4.31. The estimated value of the total ore assets on March 1, 1916, is \$798,789.00. The estimated tonnage is 53,493, including ore on dumps. The estimated value per ton is \$14.93.

No changes to speak of were made at the mill. It is impossible to make cost comparisons between this year's and last year's operations, due to the abnormal increase in the cost of supplies due to the war. In spite of the above-mentioned factors, the year shows a \$0.035 per ton milled decrease on direct costs, and a decrease in the total cost of \$0.077. In the months of January and February, 1916, the tonnage milled was reduced from 400 tons per day to 250.

Meeting of New York Section of Society of Chemical Industry

A meeting of the New York Section of the Society of Chemical Industry was held in Rumford Hall, Chemists' Club, on Friday evening, Nov. 24. The chairman, Dr. JEROME ALEXANDER, presided.

IMPORTANCE OF IMPURITIES

Two very interesting papers were presented, the first being read by Dr. Alexander on "The Importance of Impurities." The paper dealt with the influence of very small percentages of impurities in substances, and pointed out that many apparently inexplicable changes in structure and properties could be traced to minute quantities of impurities. A large number of examples were given illustrating this fact. This is a subject which warrants the closest attention and should always be borne in mind when some unusual change occurs. One of the best known examples as cited by Dr. Alexander is the influence of very small percentages of arsenic on the conductivity of copper. In electrolysis small percentages of impurities greatly effect the results, especially in plating; for example, a small amount of copper gives gold plate a red shade. Impurities are sometimes beneficial and sometimes detrimental, but they should always be taken into account. Dr. Alexander emphasized especially the need for great caution in reusing shipping containers. They should be thoroughly clean and no contaminating substance should be present as even the smallest amounts of a foreign substance sometimes cause great trouble.

TECHNOCHEMICAL PROBLEMS

Dr. RAYMOND F. BACON, director of the Mellon Institute of Industrial Research of Pittsburgh, read a very interesting paper, in which he outlined a large number of industrial problems which might be successfully attacked by our universities in their laboratories, in coöperation with the industries. For the university to coöperate with the industry it is necessary that there be a liberal exchange of problems for research and the industries must take a broader view of the subject, and not withhold necessary information.

Among the problems mentioned by Dr. Bacon were the following: concentration of brown ores of Carolina, Tennessee, Alabama, Texas and other Southern States, numerous blast furnace problems, such as the action of considerable amounts of vanadium in the furnace; utilization of gases; use of slags in ceramics. A substitute for magnesite for refractory use is badly needed, zirconia being too costly. A serious problem is the better utilization of domestic magnesite. The treatment of zinc flotation concentrates, the manufacture of retorts of higher tensile strength and greater durability, leaching of oxidized copper ores, acidity of gases from copper and lead smelters, new tonnage uses for sulphur

and arsenic, selective flotation of minerals, uses for alkaline earth metals (including alloys of calcium and their application in melting and casting of metals), chromium electroplating, production of pure titanium and zirconium, greater economy in processes of molybdenum concentration and extraction, chemical character of coal, production of smokeless fuel, determination of quality of and changes caused in oils by Fuller's earth, regenerative heating in the pottery industry, the great need for suitable refractories for high-temperature experimental work—these are some of the problems which are awaiting solution.

In the organic field first and foremost is the coal tar products industry and dyes from other sources; other problems are: new uses for pitch, use of tar from light oil, new peaceful uses for benzol and toluol, cause of corrosion in tar stills, uses for creosote oil, gasoline from coal gas (more applicable to and now under consideration in England, a non-petroleum-producing country) use of oil shale deposits, research in cotton industry as to value of various fertilizers and bleaching stained cotton, butter substitutes from soya bean oil, wax from sugar cane, ammonia recovery in beet sugar manufacture. A physicochemical problem is the action of light in manufacture of chlorides of carbon and as a catalyst in various reactions.

The above mentioned subjects do not include quite all of those mentioned by Dr. Bacon, but it is evident that there is no lack of problems awaiting solution. The field for chemical and metallurgical research of a practical nature is unlimited.

Chemistry in the Gas Industry

The third annual joint meeting of the New York Sections of the Illuminating Engineers' Society and the American Electrochemical Society, held in the United Engineering Society Building on Nov. 9, proved very interesting and enjoyable. Mr. W. Greely Hoyt presided.

Two papers were presented. The first, by Mr. W. R. ADDICKS, vice-president of the Consolidated Gas Co., gave "Some Notes on Gas Standards." The second paper, by Mr. ELMER L. KNOEDLER, on "The Most Recent Developments in Incandescent Gas Mantles." Both papers are published in full elsewhere in this issue.

Both papers were discussed together. Mr. Young, of the Public Service, pointed out the "wonderful developments in the gas-lighting industry." Mr. Forestall spoke of the great importance of adopting the heat-unit standard. Mr. Serrell said that a standard Bunsen burner was needed just as the electric lighting industry has a standard base and socket.

Dr. Fink asked whether any difficulty had been experienced with the artificial silk fiber in impregnating it with the thoria-ceria mixture. Dr. Knoedler replied that a better and much more uniform absorption is obtained with artificial silk. A very heavy mantle is used for railroad lighting, since high-pressure gas can be employed. After a vote of thanks to the authors of the papers the meeting adjourned.

Before the meeting there was a very sociable and splendidly managed informal dinner at Keene's, in a private room, with musical entertainment.

Exhibit of Electrochemical Products in New York Museum of Natural History

The American Electrochemical Society plans what should be a very interesting exhibit of electrochemical products at the New York Museum of Natural History. This will be arranged in connection with the New York convention of the American Association for the Ad-

vancement of Science during the last week in December, 1916. The attendance at the Museum during the meeting is expected to reach over 5000.

This exhibit will form a section of a general exhibit of scientific and technical products. Prof. H. F. Osborn, president of the Museum of Natural History, has assigned to the American Electrochemical Society four display cases, 8 ft. long and 2½ ft. wide and each company's exhibit will occupy about one and a half square feet. The exhibits are to be properly tagged with the name of the product and name and address of the manufacturers. The tags are to be white and are limited in size to 3 in. by 8 in.

Manufacturers, interested in the exhibit, are requested to send samples of electrochemical products, and also samples of important raw materials at the earliest possible moment to Dr. Colin G. Fink, care of Museum of Natural History, Columbus Avenue and Seventy-seventh Street, New York City.

Dinner to Dr. Takamine and Dr. Hirsch

"In honor of Dr. Jokichi Takamine and Dr. Alcan Hirsch on the occasion of their departure for Japan to collaborate, at the invitation of the Japanese government, in the development of the Japanese dye industry," Mr. Joseph P. Devine, president of the J. P. Devine Co., gave a dinner on Saturday, Nov. 18, in the East Room of the Waldorf-Astoria, New York.

Nearly forty professional friends of Drs. Takamine and Hirsch attended the function, which was exceedingly enjoyable.

The Japanese Dye Company, formed after the beginning of the European war to manufacture dyes for the Japanese market, is a private company subsidized by the Japanese government in so far as the government has guaranteed the interest on the capital provided by the investing public of Japan. This company selected Drs. Takamine and Hirsch and Mr. Devine to collaborate with them in the starting and development of the undertaking; and on the eve of the departure of Drs. Takamine and Hirsch for a three months' trip to Japan Mr. Devine tendered them this dinner.

Mr. Frank A. Palen, sales manager of the J. P. Devine Co., acted as toastmaster. The keynote of his introductory remarks was that "there is no greater factor in diplomacy than cordial business relations." Mr. Joseph P. Devine outlined his cooperation with the Japanese dye makers and emphasized his desire that they should have the advantage of our development here so as to eliminate mistakes that could not be avoided by them without previous experience.

Dr. Jokichi Takamine gave a most interesting sketch of the evolution of modern industrial and scientific Japan, while the speech of Dr. Alcan Hirsch (or Hiruchi Hakasi, by which name and title he will be known in Japan) was a fine generous expression of thanks to his friends.

Dr. Charles F. Chandler was, as ever, delightful in his recital of Takamine reminiscences; so was Dr. Charles Baskerville, who concluded with remarks on the function of science as an international catalyser; "out of all the present war turmoil science must bring about unity of nations and unity of purpose." Dr. Marston T. Bogert emphasized that in the present rapid development of industrial chemistry in this country the shortage of highly trained men, able to perform the more difficult research work, was a serious handicap. Dr. Thomas H. Norton, in the final set speech of the evening, gave interesting statistical figures of American and Japanese dye production and consumption, and paid a tribute to "the men who have so swiftly designed

and built the digesters, the sulfonators, the autoclaves, and all the manifold machinery of the color factory, and to whom our young American industry owes its rapid evolution."

Current News and Notes

Fused Silica Company Changes Hands.—The firm of Fensterer & Ruhe of 37-39 Murray Street, New York City, have recently bought the controlling interest in the Sidio Company of America, Inc., manufacturers of fused silica (quartz glass). The company's factory is being enlarged and in a short time will be completed. The New York office is at 37 Murray Street. The officers of the company are now Otto Trautmann, president; Walter J. Fensterer, vice-president; S. Herlinger, secretary; and Francis H. Ruhe, treasurer.

Electric Steel in San Francisco.—The Pacific Foundry Company of San Francisco has installed a Rennerfelt furnace of 750-lb. capacity. While not the first electric steel plant on the Pacific Coast, it is the first electric steel plant in San Francisco.

Gift to United Engineering Library.—Dr. James Douglas of New York has presented \$100,000 to the United Engineering Society, the income to be used for the benefit of the library. The trustees of the society have perfected plans for the development and the extension of the usefulness of this great engineering library and are endeavoring to secure endowments aggregating \$1,000,000, the income to be used for the library. The plans of the trustees having been submitted to and carefully examined by Dr. Douglas have been approved by him and he has signified this approval by his gift of \$100,000, which has just been made. Now that the library of the American Society of Civil Engineers has been united with the libraries of the Institutes of Mining, Mechanical and Electrical Engineers in the building of the United Engineering Society in West Thirtieth Street, New York, the combined library forms the greatest engineering collection in the world. It is the purpose of the trustees to greatly extend its usefulness and it is hoped that the splendid indorsement which Dr. Douglas has given will stimulate other similar endowments until the necessary \$1,000,000 has been obtained.

The Cutler-Hammer Mfg. Co., Milwaukee, Wis., has issued a booklet describing magnetic switch control apparatus for the iron and steel industry.

Messrs. Sill & Sill, consulting mining and metallurgical engineers of Los Angeles, Cal., have issued an "ore testing" bulletin giving an illustrated description of their facilities for testing ores and metallurgical processes.

Painting with a Gun.—The Spray Engineering Company, Boston, Mass., has issued a bulletin describing its new "paint gun," a device for applying all kinds of liquid coatings by the spraying method.

Fans.—The B. F. Sturtevant Co., Boston, Mass., has issued catalog No. 240, describing Sturtevant electric fans for various uses. Three types are shown; centrifugal, propeller and disc fans. A separate bulletin No. 228 has also been issued giving dimensions, capacities, etc., of design No. 3 multivane fans, which type was developed to have a larger outlet area for a given volumetric capacity, giving a higher mechanical efficiency at a lower velocity for a given maintained resistance.

The little monthly publication "**Power Notes**" issued by the Diamond Power Specialty Co., Detroit, Mich. has just been increased in size. The paper is available for all those interested in power plant work.

On the Formation of Columnar and of Free Crystals During Solidification

By Henry M. Howe

Let me try to explain why, in steel ingots, the formation of a columnar structure resembling that of the Palisades of the Hudson is favored by the use of cold iron molds, by "too much fire" as the crucible melter says, and in general by molten superheating: how it happens that "free crystals" form and sink to the bottom of the ingot; and why in the cross section of the ingot the transition from the columnar to the equiaxed structure is usually abrupt.

The underlying condition which leads to these several results is that each molten particle in the act of freezing splits up into a part poorer in carbon which freezes, and another part richer in carbon which, because its enrichment in carbon lowers its freezing point, fails to freeze.

THE COLUMNAR STRUCTURE

This arrest of the freezing, when as in Fig. 1 the littoral molten layer has thus been enriched in carbon and its freezing point has thus been lowered to below the existing temperature, is only temporary. The progressive cooling would itself soon bring the existing temperature down to the freezing point of this enriched layer, but apart from this the freezing point of this layer is quickly raised up to the existing temperature by the shoreward diffusion of unenriched deep sea metal. This soon dilutes the carbon content of this littoral layer enough to raise its freezing point up to the now existing temperature, when it in turn freezes.

This diffusion clearly feeds the freezable deep sea metal faster to the tips of the pine-tree crystals which protrude from the already solid shores into the molten mass than to their lateral branches, so that growth tends to take place fastest at these tips. Hence the columnar form. Moreover, rapidity of cooling exaggerates the

advantage which these tips have in this regard, and so does quiet, because the existence of irregular convection currents would tend to feed deep sea metal to the ends of the lateral branches.

The use of chill molds, then, by hastening the cooling, favors the growth at the tips of the existing pine-tree crystals, or in other words favors the formation of columnar crystals.

Molten superheating favors quiet, and through quiet the columnar structure, probably in part by decreasing the quantity of dissolved gases, and hence by postponing the period when those gases become so concentrated in the residual molten as to supersaturate it, and hence to begin escaping, because it is probable that the solubility of gas in molten metals, as in aqueous liquids, decreases as the temperature rises. In the case of the crucible process, both long and high heating further favor quiet by increasing the silicon content of the molten metal, for they lead to the reduction of silica from the walls of the crucible and from the slag. A like action occurs also in the acid open-hearth process.

A distinct way in which rapidity of cooling, quiet, and molten superheating lead to rapid freezing is their increasing the undercooling, the degree to which the temperature sinks below the freezing point before freezing starts, with the result that, when this undercooling once breaks up and freezing actually begins, it proceeds with extreme rapidity, indeed almost instantaneously, with the shooting out of columnar crystals, a shooting which is retarded progressively as the heat evolved by the solidification raises the temperature of the metal toward its freezing point.

THE FORMATION OF FREE CRYSTALS

Because the heat can escape only through the sides, top, and bottom of the solidifying ingot, the temperature naturally rises as we pass from the outside toward the axis. Because the molten metal in immediate contact with the already solidified part of the ingot should thus be somewhat cooler than that farther off from these walls, solidification would naturally be expected to occur only where the molten abuts against the walls, so that every new particle of pasty solid which forms should attach itself to them. How then can free crystals form at an appreciable distance from the walls? Let me offer an explanation based on this same principle of the differentiation which occurs in freezing. Let us call the layer of molten metal of Fig. 1 immediately in contact with the already solid walls Layer 1, and that next farther from them Layer 2. At any given moment Layer 1, enriched in carbon by the freezing of the last deposited relatively carbon-poor layer, is richer in carbon than layer 2, and hence has a lower freezing point. Hence freezing may occur in layer 2 before it does in layer 1, because the general fall of temperature may bring layer 2 to its somewhat higher freezing point before it brings layer 1 to its somewhat lower one, and thus solid nuclei may form in layer 2 while layer 1 is still molten. These nuclei, lacking contact with the solid walls, are in fact "free crystals." As each of these particles in layer 2 freezes, it breaks up in turn into a part poorer in carbon which freezes, and a part richer in carbon which remains molten. Hence each little nucleus which thus freezes is in turn poorer in carbon than the molten metal in which it is suspended, hence it is heavier than that metal, and hence it sinks to the bottom. The accumulation of sinking free crystals explains the usual impoverishment in carbon of the lower axial part of ingots which are segregated.

As with the progress of solidification the thermal gradient becomes flatter and flatter, while the carbon-gradient probably becomes steeper and steeper, the layer of most active solidification should move farther and

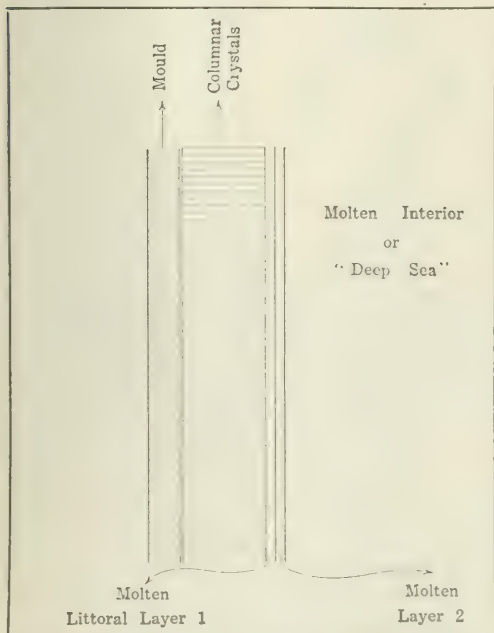


FIG. 1.—PART VERTICAL SECTION OF A SOLIDIFYING STEEL INGOT

farther axisward, or in other words solidification should occur at points farther and farther away from the already solid walls.

These considerations evidently apply to solidifying liquids in general, and even to those cases in which gases pass directly to the solid state. They apply even to so-called pure metals and other pure substances, provided that they contain dissolved gases, which concentrate progressively in the residual molten as other dissolved substances do.

WHY THE TRANSITION FROM THE COLUMNAR TO THE EQUIAXED REGION IS ABRUPT

During the early part of the freezing the thermal gradient is so steep that our layer 2, in spite of being poorer in carbon than layer 1, yet does not in cooling reach its freezing point before layer 1. Whether layer 2 can reach its somewhat higher freezing point earlier than layer 1 can reach its somewhat lower one will clearly depend on how much hotter layer 2 is than layer 1. So long as the difference in temperature between layers 1 and 2 exceeds the difference in their freezing points, layer 1 will freeze before layer 2. It is only when this condition is reversed and the difference in temperature is less than that in freezing point that layer 2 can be the first to freeze. But this difference in temperature must clearly decrease as the thermal gradient flattens with the progress of solidification. This means that at a certain moment during solidification the progressive flattening of the thermal gradient will at last cause the difference in temperature between layers 1 and 2 to become less than their difference in freezing point. Up to this moment freezing has been taking place exclusively in contact with the already solid walls, and hence has been of the columnar type. From this time on free crystals form which are not in contact with those walls, and this arrests the prolongation of the columnar structure. Hence the abruptness of the transition from the columnar to the granular type of solidification.

A column prolongs itself by causing its orientation to be adopted by each new lot of solid which deposits at its existing tip, and this it must needs cease to do when it meets the crystalline growth shooting out from such a nucleus formed in Layer 2, because this latter growth will already have the orientation given by its own nucleus. Once the growth of the column has thus been interrupted, there is nothing to cause it to start again. Hence both the permanence and the abruptness with which each column, on meeting such an independent growth, loses its power of prolonging itself.

Further study may, indeed, show that variations in the relation between the thermal gradient and the freezing-point gradient form an important underlying cause of the favoring of the columnar structure by rapid freezing, quiet, and molten superheating. Evidently rapid cooling, by steepening the thermal gradient, must needs postpone the moment when the temperature difference between adjoining layers becomes less than their freezing-point difference, and in this way it favors the columnar structure. A high casting temperature would have a like effect.

We can arrive at the full explanation of these complex phenomena only by trial and error. As we amplify our explanations and bring in new principles, we indeed explain more and more of the phenomena, but we may find still a residue of facts which we cannot yet explain fully. This residue proves that still another principle remains to be discovered. By taking each of these little steps in explanation we help to the final true solution, our very failures stimulating others to try where we have failed.

Refracted Light, N. Y.

Notes from the Palmer Physical Laboratory

A Mechanical Property of Certain Magnetized Bodies

By E. F. Northrup

The writer, while experimenting with an impedance used in some alternating-current measurements, observed an interesting phenomenon in connection with this impedance. The impedance consisted of a bundle of soft-iron wires, all of equal length, which formed the core of a solenoid. This solenoid was proportioned somewhat as shown in section at *S* and in end view at *E*, Fig. 1. It was about 30 cm. in length.

Some of the iron wires having been removed from the solenoid as originally constructed left the remainder loosely crowded together within the solenoid. On applying to this solenoid a heavy alternating current, the wires near the axis of the solenoid began to slowly move out of the solenoid, although this latter rested in a horizontal position on the table.

After a brief time the wires in the solenoid had assumed the position indicated by the dotted lines in *S*, Fig. 1. They extended from one end of the solenoid to form the cone included between the points *a*, *b*, *c*, on the diagram, there being, of course, at the other end of the solenoid a corresponding hollow cone marked by the dotted lines *a-c* and *b-c*.

In seeking an explanation of this phenomenon the wires were pushed back within the solenoid so that their ends formed level surfaces at each end of the solenoid. It was then found on applying the current that the extended cone of wires could be made to form itself at either end of the solenoid by giving one or more of the central wires a slight thrust in the direction in which it was desired to have the cone form.

With the above observation as a hint to start from

it was easy to make the following general deduction:

If a thick sheet of magnetizable substance be magnetized with north magnetism uniformly distributed over one surface and south magnetism uniformly distributed over the opposite surface, then any elementary cylinder of this magnetizable substance, having its axis perpendicular to the upper and lower planes of the sheet is, when located away from the edge of the sheet, mechanically in unstable equilibrium. Conceive this small cylinder of the material capable of free motion in the direction of its axis. Then it is evident that if the cylinder be moved ever so short a distance in the direction of its axis the end which projects slightly above the general surface of the sheet will acquire a polarity of the same sign as the magnetism of that side of the sheet above which the end projects. But now, as poles of like sign repel each other, the projecting end of the cylinder will be repelled by the magnetism spread over the surface of the sheet and the cylinder will be pushed out of the sheet its entire length. This will occur so suddenly that its momentum will carry the

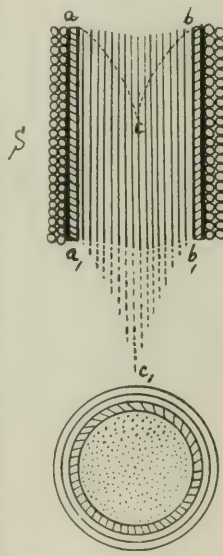


FIG. 1—SOLENOID WITH MOVABLE CORE

lower end of the cylinder slightly above the surface of the sheet. But this lower end of the cylinder will now acquire by induction magnetism of the opposite sign to that spread over the surface of the sheet, and the cylinder will have its lower end attracted and brought into contact with the surface of the sheet in the near neighborhood of the hole from which it made its exit, and will there remain standing in a position in which its axis is normal to the surface of the sheet.

To test the above deduction one of the writer's former students, Mr. Dudley Willcox, constructed, at the writer's request, the piece of apparatus which is illustrated at *S* and *T*, Fig. 2. We called this piece of apparatus our magnetic "Jack-in-the-Box." The name is seen to be well applied when the performance of this magnetic curiosity is witnessed. A word respecting its construction before describing the manner in which it works. *I*, shown in vertical section, was a cylinder made of ordinary cold-rolled steel shafting. A hole approximately 3 mm. in diameter was drilled along its axis entirely through it. The bottom end of this hole was fitted with a small brass plug 3 mm. long and a hole in this, to admit air, was drilled lengthwise. A rod of soft iron, *i*, was made to accurately fit this hole, but left free to move within it without friction. The iron core *I* was wound with several layers of No. 16 copper wire. In Fig. 2 are shown the various parts as proportioned and of natural size. To make our Jack-in-the-Box more entertaining the upper end of the movable iron rod *i* was capped with a piece of sheet brass, to which a piece of cardboard could be glued with the smiling face of our Jack-in-the-Box painted upon it.

When to this device a magnetizing direct current, derived from 48 volts of storage battery, was suddenly

applied by closing a switch and keeping it closed, the central rod *i* would spring upwards and assume the position shown in dotted line in Fig. 2. The suddenness with which the rod *i* would move up out of the solenoid and assume its position, standing on top of the iron core piece *I*, was such that the eye could not follow the motion.

It is evident that, if the diameter of the movable portion *i* of the iron core be chosen nearly equal to the diameter of the immovable portion *I*, the movable portion instead of showing a tendency to be projected upwards and out of the solenoid would be, as is usually

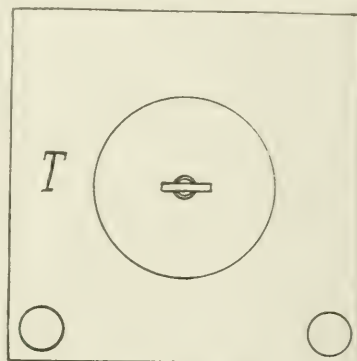


FIG. 2b—TOP VIEW

observed, drawn into the solenoid. It follows that it would be possible to so choose the diameter of the movable portion of the core that on energizing the solenoid this iron core-piece would have neither a tendency to be sucked into the solenoid or to be projected out of it. A similar result could be obtained by decreasing the magnetic permeability of the immovable portion of the core *I* while keeping the size and permeability of the movable portion *i* unchanged.

The writer takes this occasion to suggest that experimenters should endeavor to hold a mental grip on chance observations of apparently trifling phenomena until they have deduced all the consequence which can possibly be drawn therefrom. The cultivation of a mental habit of this kind will rarely fail to lead the investigator to matters of much interest and often of large commercial utility.

Palmer Physical Laboratory, Princeton, N. J.

Coals of Canada.—The Mines Branch of the Department of Mines of Canada, has issued a bulletin (No. 338) entitled "The Weathering of Coal," by Dr. John B. Porter. The report is a supplement to Bulletin 83 on the coals of Canada issued in 1910. It contains the results of an extended investigation.

Dust Collecting and Conveying Apparatus.—The B. F. Sturtevant Company, Boston, Mass., has issued catalog No. 235 describing Sturtevant dust collecting and conveying apparatus.

Stoneware Atomizing Nozzles for Acid Chambers.—Stoneware atomizing nozzles, as a substitute for glass nozzles in acid chambers, have been placed on the market by the Monarch Manufacturing Works of Philadelphia, Pa. There is claimed to be no danger of breakage due to temperature changes, and they are not affected by acids such as sulphuric, nitric, etc. The inner part (sprayer) is also made of stoneware and is loose-fitting so that no adjustment is needed when replacing the inner part after cleaning.

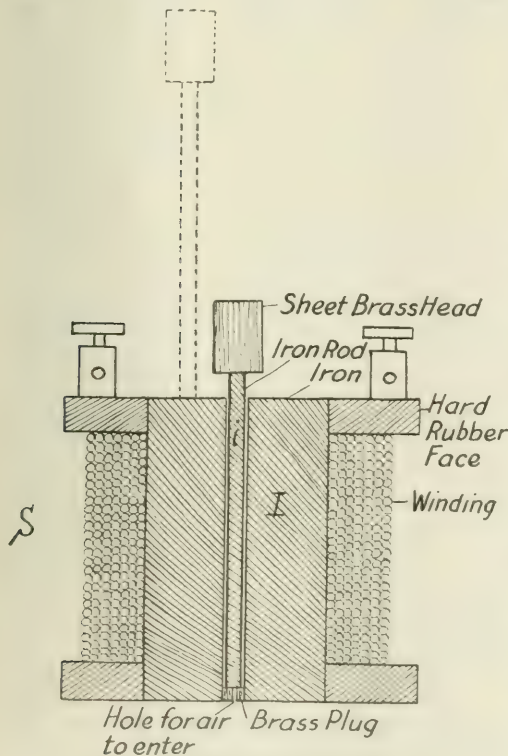


FIG. 2a—MAGNETIC JACK-IN-THE-BOX

Determination of Light Oils in Coal Gas and Description of Still for Separating the Light Oils from the Absorbing Oil

By D. H. Duvall

Chemist, Coke Plant, Bethlehem Steel Company,
Maryland Plant, Sparrow's Point, Maryland.

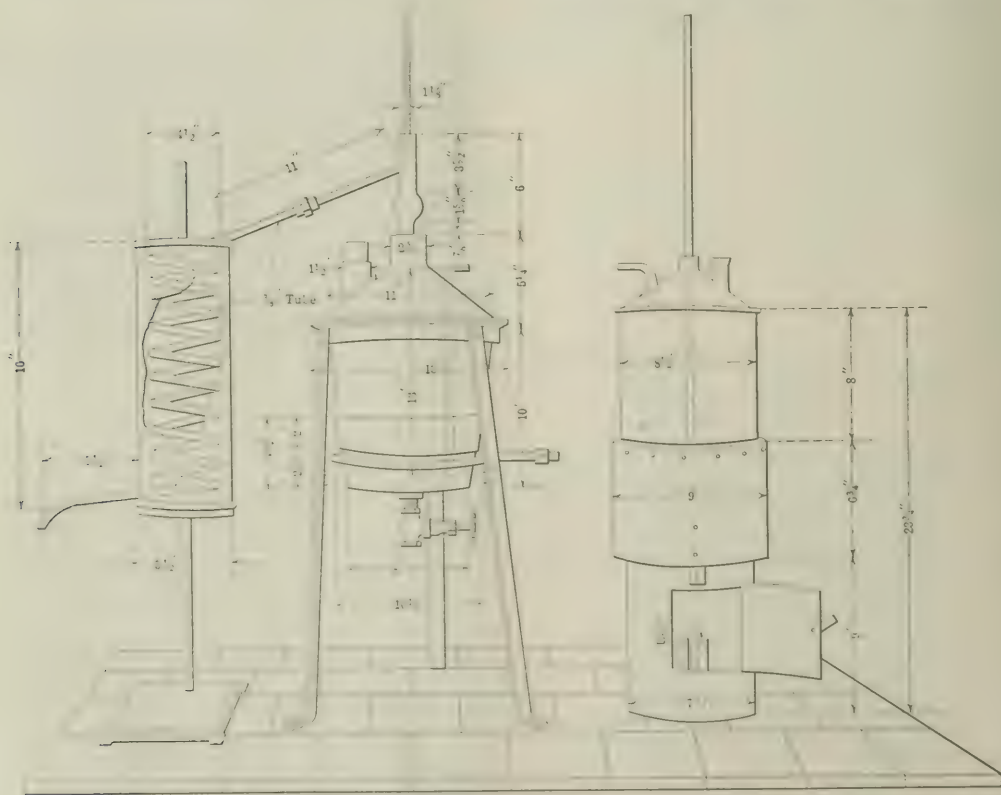
The recent development of the light oil recovery in connection with by-product coke plants in this country has made it necessary to determine the quantity of light oils in the gas (both before and after scrubbing) to show the efficiency of the operation. Since determinations are required frequently, it is necessary to employ a method that will lend itself readily to routine laboratory work. From various laboratory methods we have developed an apparatus which has met the necessary requirements very satisfactorily, and owing to numerous requests for information regarding this apparatus we take this opportunity to give a brief description of the method and apparatus.

Before proceeding with the description of the apparatus it will be necessary to give a brief outline of the method for those who are not so familiar with it. The complete test consists of the absorption of the light oils by some absorption medium and the separation of the light oils from this medium. The first part of the test is accomplished by freeing the gas from hydrogen sulphide and naphthalene by means of a solution of sodium hydrate for the removal of the hydrogen sul-

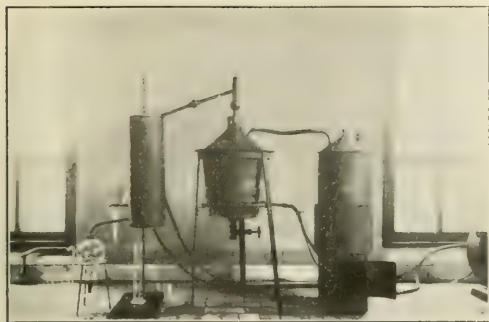
phide and a solution of picric acid for the removal of naphthalene, then removing the light oils by contact with a suitable absorption medium, preferably oleic acid. The absorbing solution is placed in a train of five or six bottles, each bottle containing about 1000 to 1200 c.c. The gas passes from the train through a wet gas meter, by means of which the corrected volume is determined. The rate at which the gas is passed is from 3 to 4 cu. ft. per hour, depending upon the quantity of light oils in the gas.

The second part of the test consists of the separation of the light oils from the oleic acid, which is accomplished by means of the still shown in the photograph and sketch. The still, which is made of 12-gage copper, is shown in the sketch, with proportions and actual dimensions, while the photograph shows the still as arranged for use. It has capacity great enough to hold sufficient oleic acid to scrub enough gas to produce an accurately measurable quantity of light oils without enriching the oleic acid to a point where complete absorption would not be obtained. The condenser attached to the still gives the distillate sufficient cooling contact to insure perfect condensation of the oil vapors. The benzolized oleic acid is poured into the still through the filling cap at the top and the debenzolized oil (after the distillation is complete) is drawn off through the valve at the bottom of the still, without breaking any connections or moving it out of position.

Heat is applied to the still by means of the circular Bunsen burner shown in the sketch. The orifices of



DETAILS OF APPARATUS FOR DETERMINATION OF LIGHT OILS IN COAL GAS



APPARATUS FOR DETERMINATION OF LIGHT OILS

the burner are drilled at an angle of 45 deg., so that the tips of the flame will strike against the 2-in. wide copper band sweated on to the still as a reinforcement to prolong the life of same.

The still is heated until the temperature at the top is 80 deg. C., then the temperature of the oil is about 100 deg. C. When this temperature is reached, steam from the generator is introduced into the still by means of stout rubber tubing connection. The temperature at the top of the still rises rapidly to 100 deg. C. and then increases slowly to 180 deg. C. The temperature of 180 deg. C. can be reached in an hour without the slightest danger of boiling over the contents of the still.

The distillate from this operation is drained of water and a dry distillation made in a 200 c.c. side neck Engler flask to get rid of excessive oleic acid, which is carried over mechanically during the process of distillation. The distillate from this dry distillation is now saponified with sodium hydrate to remove the last traces of oleic acid, washed with water to remove the products of saponification and sodium hydrate, drained of water and dried with calcium chloride, after which a fractional distillation is made in a 200 c.c. side neck Engler flask.

Having given the volume of gas used in the test and the quantity of oils as obtained from the last fractional distillation, we are enabled to calculate the theoretical oils contained in a gas. Knowing the volume of gas produced per ton of coal carbonized and the quantity of light oils obtained per ton of coal in our operation, we can easily determine the efficiency of our plant operation by comparing the theoretical results with the results actually obtained in operation.

Electric Power Development in Norway.—Approval has been given by the local authorities of Gjerstad and Bremanger, Norway, to raise loans to develop water power for electrical industries in those localities for lighting and electrochemical industries. The communal administration of Jevnaker, Lunner, Gran and Grandbu have appropriated \$134,000 to enlarge the Hadeland electric station. The Bremanger Power Co. will erect a factory for producing carbide and cyanamide, producing 30,000 tons of carbide per year, of which one-third will be used for making cyanamide. A French-American syndicate is considering the erection of a large electrochemical plant in the Telemarken district, using 100,000 hp. from the Maar Falls in Tinn.

The B. F. Sturtevant Company, Boston, Mass., has issued catalog 235 describing Sturtevant fan systems for collecting dust and conveying materials.

Manufacture of Potassium Chlorate

By Anson G. Betts

The electrolysis of potassium chloride solution results in the formation of chlorate, but special means have to be employed to make the process successful enough to be commercial.

The first attempts to produce chlorates electrolytically were made with carbon anodes and carbon or iron and other metallic cathodes constituting a very inefficient plant, cathode reduction destroying the product about as fast as produced.

The addition of magnesium chloride or calcium chloride was tried, on the theory that a deposit of the corresponding hydrate on the cathode would hinder the reducing effect of the cathode. A laboratory trial of this procedure will convince any one that the benefit of these salts is very little.

The patent of Imhoff disclosed a beautiful process. Platinum electrodes are used, with a neutral solution containing a soluble chromate and a very high current efficiency is the result. Considering the ease of recovering the product in crystal form, by merely cooling the electrolyte, this manufacture is extremely easy and simple.

At the present time potassium chlorate is selling at many times the normal price. The high price of potassium chloride accounts for this to a partial extent only.

Presumably the supply has not kept pace with the demand because while the Imhoff patent has expired, platinum electrodes are required, and platinum at present prices is not an attractive large investment and heavy interest charges have to be figured on.

The process of the writer solves several serious obstacles in the way of profitable production of potassium chlorate, at this or at any time.

Experiments show that the electrolysis of alkaline chlorides with carbon anodes and magnesium cathodes¹ give a high current efficiency and low cathode reduction of the product.

The use of a very open diaphragm is desirable, not dense enough or close enough to make an absolute separation of the anode and cathode liquors, but to impede the free circulation in the cell only. The result is the maintenance of an acid reaction near the anode and a basic reaction at the cathodes. The acid anolyte has a minimum destructive effect on the anodes and accelerates the conversion of hypochlorite into chlorate, and depresses the amount of oxygen liberated, while the basic reaction of the catholyte prevents the corrosion of the cathode. A bank of glass rods separated by small spacing, hung or supported between the electrodes gives the desired effect.

For raw material, it is proposed that feldspar be utilized. By heating ground feldspar with lime and salt, and lixiviating, a solution of salt and potassium chloride is readily obtained.² As a means of producing potassium chloride, the necessity of separating these salts might deter anyone from working this process, but in the manufacture of chlorate the mixed chlorides can be electrolyzed and the potassium chlorate crystallized out. The cost of the raw material by this procedure is certainly reasonable and cheaper than potash salts.

Using feldspar as raw material, the cost of production with water power figures out roughly at about 6 or 7 cents per pound of potassium chlorate under present conditions.

Asheville, N. C.

¹Bureau of Soils, U. S. Dept. of Agriculture—Circular No. 71.
²U. S. Patent, A. G. Betts, 918,650, Apr. 20, 1909.

Possibilities in the Wet Treatment of Copper Concentrates*

By Lawrence Addicks

At the San Francisco meeting of the Institute last year I presented, through the courtesy of Dr. James Douglas, some results of experiments on the roasting and leaching of concentrator tailings.¹ After it became apparent that flotation rather than leaching was clearly the better method of handling the particular problem under consideration, before dismantling the experimental equipment, some data was secured on roasting and leaching the concentrate itself in competition with smelting. Some of the results obtained are given in the following paper and they are of particular interest at this time in view of the large quantities of flotation concentrates with their somewhat difficult smelting characteristics now being produced.

A complete wet process (patent applied for) consists

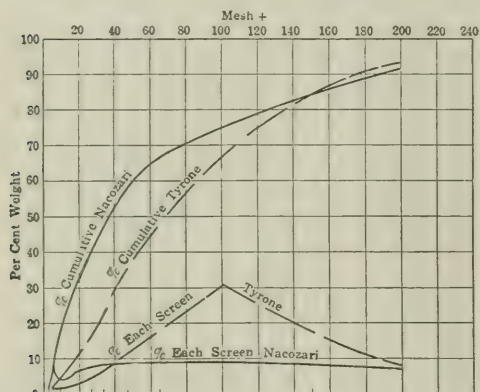


FIG. 1—SCREEN ANALYSIS OF CONCENTRATES CALCINES

of roasting and leaching the calcines in dilute sulphuric acid produced from the roaster gases, roasting the residue with salt and leaching with dilute tower liquors (the well-known Longmaid-Henderson process) and recovering the copper, silver and gold by cementation or electrolysis or a combination of both. It is evident, however, that the residue from the first leaching, carrying about 20 per cent of the copper and all of the silver and gold, can be smelted if preferable. In considering the application of the scheme to individual cases, it must be remembered that freight plays a large part in any reduction process wherein smelting is not conducted at the mouth of the mine, and that it is not practicable to-day to build small smelting plants for individual operations.

The experiments may be grouped under four main heads: Roasting, leaching, chloridizing residue, and recovery of copper from solutions. The products of two concentrators were used: The Nacozari concentrates were the product of a large modern mill not using flotation, the copper mineral be-

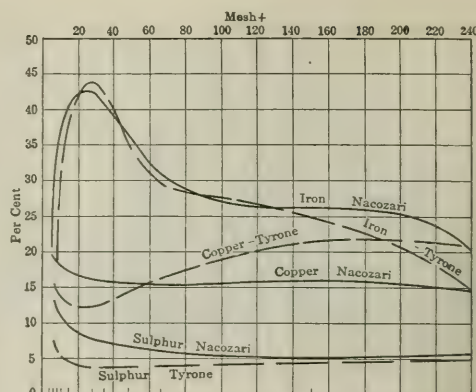


FIG. 2—VARIATION OF COMPOSITION WITH SIZE OF PARTICLE

ing largely chalcopryite; and the Tyrone concentrates, the product of an experimental mill including flotation, the copper mineral being chiefly chalcocite. Typical analyses would be as follows:

	Nacozari	Tyrone
Copper, per cent.	14.0	14.0
Silver, ounces per ton.	4.0	0.5
Gold, ounces per ton.	0.01	Trace
Iron, per cent.	31.0	28.0
Sulphur, per cent.	34.0	30.0
Silica, per cent.	13.0	...
Alumina, per cent.	3.0	...
Lime,	0.6	...

Fig. 1 shows screen analyses of calcines obtained by dead roasting the two concentrates as described later. Fig. 2 shows the analysis of the calcines for copper, sulphur and iron for each screen size. The Nacozari concentrates carry considerable coarse jig product, while the Tyrone material comes from an ore where the values are finely disseminated and the quantity of 100-mesh is quite marked. The presence of the flotation concentrates in the Tyrone material brings up the copper contents of the fine sizes.

Roasting

The object in roasting is to make as much of the

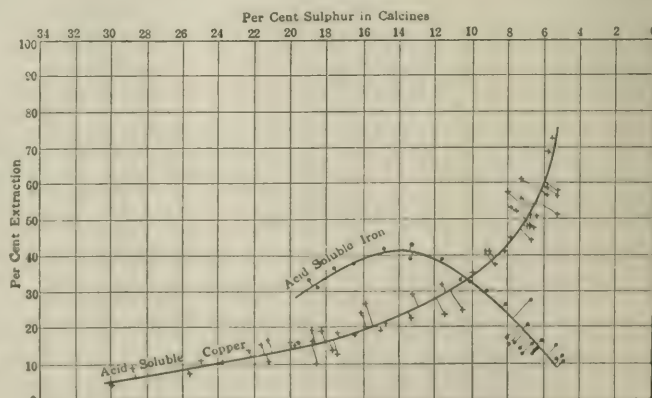


FIG. 3—NACOZARI CONCENTRATES ROASTED IN 18-FT. SIX-HEARTH MACDOUGALL FURNACE AND LEACHED IN 4 PER CENT SULPHURIC ACID IN LABORATORY

* A paper read at the Arizona meeting of the American Institute of Mining Engineers, September, 1916.

¹ METALLURGICAL AND CHEMICAL ENGINEERING, September 1, 1915.

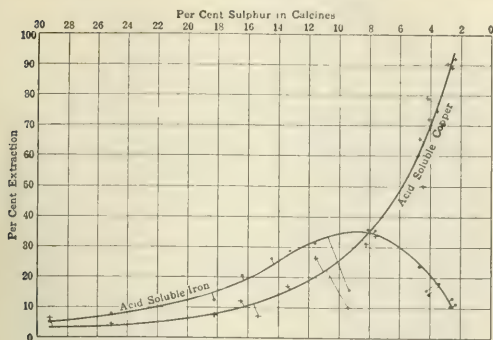


FIG. 4—TYRONE CONCENTRATES ROASTED IN 18-FT. SIX-HEARTH MACDOUGALL FURNACE AND LEACHED IN 4 PER CENT SULPHURIC ACID IN LABORATORY

copper, and as little of the iron as possible soluble in dilute sulphuric acid. The work is similar to roasting pyrites fines in sulphuric acid manufacture, except that this solubility ratio rather than the complete utilization of sulphur is the controlling factor. Small-scale work is not very satisfactory as a guide to possible results as it is practically impossible to prevent overheating due to rapid oxidation of sulphur in a laboratory experiment. An 18-ft., water-cooled, six-hearth MacDougall was used, the speed of rotation being gradually cut down until dead roasting conditions were obtained. Greater tonnages could doubtless have been obtained in a seven-hearth furnace.

Many samples were taken from various hearths and the acid-soluble copper and iron determined by leaching with 4 per cent H_2SO_4 in the laboratory. The results of these tests are given in Figs. 3 and 4. The results of tests on a series of sixth-hearth samples to determine the relation between tonnage and sulphur elimination are plotted in Fig. 5. It is evident that the chalcocite can be oxidized much more readily than the chalcopirite, although size of particles has something to do with this. An investigation of the solubilities of the various sizes of particle are carried out by screening some of the calcines, as shown in Fig. 6. As would be expected, the finer particles are the more thoroughly oxidized; the jig product in the Nacozari concentrate is one reason for the poorer results obtained in the treatment of this material.

In general, these large-scale experiments indicate the possibility of reasonably obtaining the results desired—

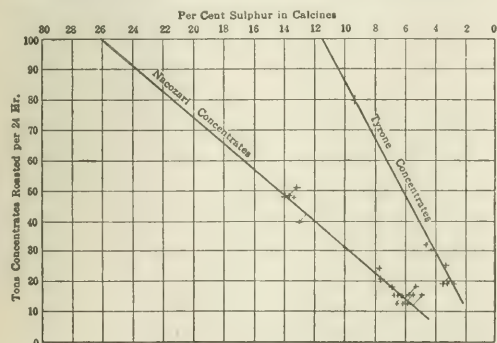


FIG. 5—ROASTER CAPACITY VS. ELIMINATION OF SULPHUR

high copper and low iron solubility—but it is obvious that the residue after leaching will contain sufficient copper values to require retreatment, aside from the fact that any silver and gold will remain in this residue.

Leaching

As shown in the paper presented last year, such satisfactory results in the extraction of copper values from tailings were obtained by dumping the hot calcines from the furnace into a leaching trough, the few seconds' agitation thus obtained extracting almost as much as prolonged treatment in other apparatus, that the same idea was tried out with the concentrate calcines. It was not possible, for various reasons, to handle the output of the furnace directly, so the calcines were stored and then fed to a bucket elevator which in turn delivered into a V-trough in which the leaching liquor was flowing.

The results were here disappointing, as although there was instant extraction of perhaps half of the soluble copper, a prolongation of the trough to give 60 sec. travel did not greatly increase this amount. It was definitely shown in the laboratory as well that prolonged agitation was necessary to extract all of the

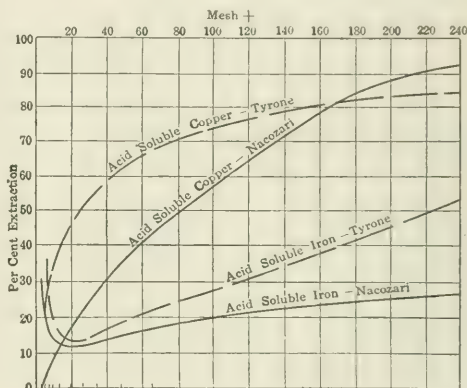


FIG. 6—RELATIVE SOLUBILITIES OF SIZED PARTICLES OF CALCINE

soluble copper. The leaching trough delivered into an acid-proof drag consisting of an endless belt with angle rakes, of the type commonly used in concentrators for dewatering. This acted more or less as a classifier, the very fine residues being carried over with the liquor, from which they were subsequently separated by settling. As this still gave insufficient agitation to the sands, a Parral tank was tried, but it was found that they were too heavy to yield readily to any sort of air-lift agitation.

A Dorr classifier was then added to the apparatus, and this did better. It was found, however, that it was necessary to pass the residues six or seven times through the leaching process in order to obtain an extraction equal to that shown by laboratory tests on the calcines.

The large-scale leaching tests were confined to the Tyronne material, a lot of 30 tons of calcines from some of the roasting tests being used. The first runs on a lot of 17 tons of not quite dead-roasted material running 4 per cent sulphur gave results that were satisfactory except in that too much iron was dissolved, causing a needless consumption of acid and embarrassing any electrolytic scheme of recovery. Later, better-

roasted material was available and a careful record kept of the metal balance and acid consumption, with the following results:

Time Through	Per Cent Cu in Tails	Through Fed	Dorr Fed
1st	7.7	Acid	Water
2d	6.0	Acid	Water
3d	5.2	Acid	Water
4th	3.6	Acid	Water
5th	3.3	Acid	Water

EXTRACTION BY HEADS VS. TAILS

	Weight, Pounds	COPPER		IRON		ALUMINA	
		Per Cent	Pounds	Per Cent	Pounds	Per Cent	Pounds
Heads	8,360	15.48	1,292	31.00	2,590	5.60	468
Tails	5,600	3.50	196	43.52	2,440	7.02	393
Extraction		84.70	1,096	5.80	150	16.00	75
Extraction per lb. of Cu		1.00		0.14		0.07	

EXTRACTION BY ANALYSIS OF LIQUORS

	Weight, Pounds	COPPER		IRON		ALUMINA	
		Per Cent	Pounds	Per Cent	Pounds	Per Cent	Pounds
Heads	51,538	0.46	238	0.20	140	0.47	246
Tails	86,910	1.46	1,271	0.76	637	0.45	395
Extraction		80.00	1,033	21.30	553	31.90	149
Extraction per lb. of Cu		1.00		0.53		0.14	

These figures check reasonably close except in the case of iron; but it must be remembered that various iron parts in the apparatus used were attacked by the liquor, which would artificially increase the iron taken into solution.

The acid consumption was 2495 lb. of 100 per cent H_2SO_4 for the run. This is equivalent to 2.28 lb. per pound of copper extracted. Laboratory tests on the same calcines indicated 2.0 lb. The leaching was done at about 125° F. with 5.6 per cent free acid in the liquor entering the trough.

In general, when a 15 per cent copper calcine is fed to

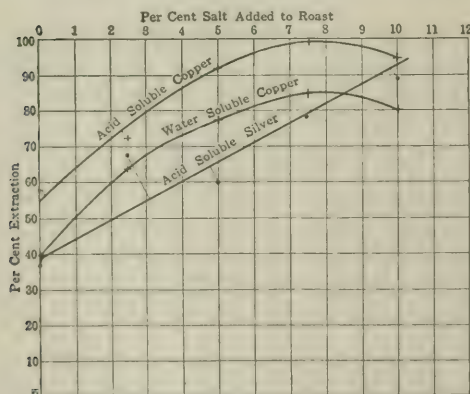


FIG. 7—CHLORIDIZING LEACHED CONCENTRATES CALCINES

Roasted 1½ hours at 975 deg. Fahr. with addition of salt and 10 per cent raw concentrates.
Calcines: 5.6 per cent copper, 1.9 oz. silver and 2.5 per cent sulphur.

Raw concentrates: 14.4 per cent copper, 0.55 oz. silver and 34 per cent sulphur.
Liquor: 5 per cent Na_2SO_4 , 5 per cent $NaCl$, 5 per cent $FeCl_2$ and 0.5 per cent $HCl + H_2SO_4$.

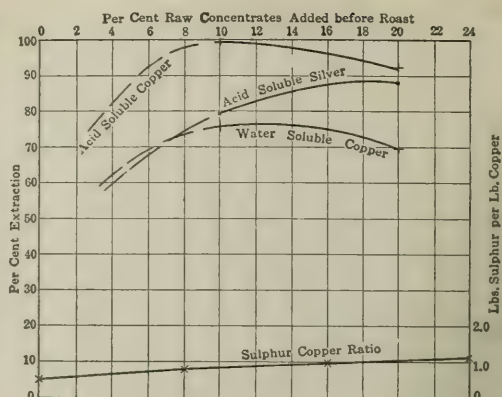


FIG. 8—EFFECT OF SULPHURIC-COPPER RATIO UPON EXTRACTION 7½ PER CENT SALT ADDED TO ROASTING "MIX"

the trough, the residue at the end of the trough will run about 8 per cent Cu, the extraction representing the instantaneously soluble copper. This residue can be brought down to about 3.5 per cent Cu by suitable agitating means, with a consumption of a little over 2 lb. of acid per pound of copper, and with the extraction of but little iron. The final residue weighs but about 60 per cent of the original concentrate before roasting.

Chloridizing Residue

No large-scale work was done on the chloridizing of the residues from the first leaching. The analysis of these residues, however, differs from that of pyrites cinder, so long successfully treated by this process, only in the amount of silica present. Various small-scale experiments were tried and 50 lb. or so were sent for test to a plant where the Longmaid-Henderson process was in operation. Both sets of experiments were entirely satisfactory.

A small lot of leached residues was prepared for test. These contained 5.6 per cent Cu, 1.09 oz. Ag, and 2.5 per cent S. Raw concentrates for adjusting the sulphur-copper ratio were used, containing 14.4 per cent Cu, 0.55 oz. Ag, and 34 per cent S. Fig. 7 shows the extractions with varying percentages of common salt added to the "mix" after roasting in an electric muffle furnace 1½ hr. at 975° F. and leaching in a liquor carrying 5 per cent Na_2SO_4 , 5 per cent $NaCl$, 5 per cent $FeCl_2$, and 0.5 per cent $HCl + H_2SO_4$. Fig. 8 shows the effect of varying the sulphur ratio. The results show a 99 per cent copper and a 79 per cent silver extraction. The report on the lot of residues sent away fully confirmed these results.

Recovery of Copper from Solutions

The liquor from the chloridizing plant would doubtless be reduced to argentiferous copper cement by iron. But 20 per cent of the original copper is involved. The sulphate liquor from the first leach could be precipitated by iron if desired, or with certain limitations would be suitable for electrolytic deposition of the copper and regeneration of the acid. The concentrates carry from 1 to 2 lb. of sulphur per pound of copper, equivalent to from 3 to 6 lb. of 100 per cent H_2SO_4 , less process losses, if the roaster gas is oxidized to sulphuric acid. Since the leaching calls for but a little over 2 lb. of acid per pound of copper, plus tailings losses, it would seem possible, therefore, to figure on a simple cementation plant, considering electrolysis as a competitor on a basis of relative profit and not of necessity.

The Cost of Coal*

By Geo. Otis Smith and C. E. Leshner

United States Geological Survey.

The price of coal is a matter of vital concern to the average citizen. No less important, however, is the question what our coal actually costs to produce and the interest in this subject is typical of the popular interest in the large productive enterprises of the country. As citizens we recognize the consumer's dependence upon the producer and are taking advanced ground as to their relative rights. In few industries does this dependence seem more vital or the consumer's equity appear larger than in that of producing and selling coal. The per capita annual expenditure for the useful metals is roughly equivalent to that for coal, but few citizens purchase pig iron or bar copper, whereas of the urban population only the dwellers in apartments, boarding houses, and hotels are spared the necessity of buying coal. The consumption of coal in the United States for heating and cooking is between 1 and 1½ tons per capita. A careful estimate for 1915 is 1.1 tons, which happens to be identical with the figure determined for similar consumption in Great Britain in 1898. This non-industrial consumption is greatest in cities and in the city of Chicago in 1912 it was nearly 2 tons. Of course, every citizen indirectly pays for his share of the total consumption, which last year amounted to 4.6 tons per capita.

Again it may be that because to a larger degree the cost of metals is charged to capital outlay rather than to the operating expense of life, we appreciate less keenly the unit price of these materials that are not immediately consumed with the using. At any rate, public opinion is more easily brought to a high temperature by considering the price of coal than by considering the price of any other product unless we except gasoline, recent discussion of which has been almost explosive.

Looking backward as well as forward, one need not be an alarmist to suggest that in the whole field of productive business the coal industry seems the one most likely to be threatened with Government operation. The foodstuffs are produced on land owned and operated by the millions, and so far as the production of the raw material for them is concerned, "monopoly" is an unknown word, but when we think of coal, terms like "barons" and "trusts" instinctively come to mind. For these reasons the determination of certain facts connected with coal production and the analysis of the cost elements that enter into the price of coal constitute a timely subject for discussion.

In discussing costs, however, we do not overlook the too evident fact that at times price may far outstrip cost. The price of coal depends upon the balance between necessity for fuel on the one hand and ability to produce and to deliver on the other; the ability to produce is in turn controlled by the labor available and the ability to deliver is dependent upon car supply. Increased foreign demand for American coal, large industrial consumption, unusual weather—all may have great influence on the current price of coal, but none of these is to be considered a factor in the actual cost of production except so far as it causes irregularity in operating expenses and promotes a decrease in efficiency of mine labor. To-day high prices are being received for coal by those who are able to produce and deliver more than their outstanding contracts require. In other words, a few traders may be able and willing to capitalize the urgent necessity of the consumer and their own ability to deliver. The premium for fuel now be-

ing paid generally by the consumers of the country and by such traders as have been caught short in their contracts is in reality not properly chargeable to cost of coal but to cost of car and labor shortage, just as in the times of stress accompanying labor troubles the premium paid by their consumers is a part of the price the country pays for strikes.

FOUR ITEMS OF COST OF COAL

Four general items of cost must be considered as normally controlling the price of coal to the consumer—resource cost, mining cost, transportation cost, and marketing cost. Under usual conditions each of these items includes a margin of profit which may seem either excessive or inadequate, according to your point of view. Yet an unbiased consideration of these cost items is absolutely essential as a preliminary to the decision by the public whether we are buying coal at a fair price, and if not why not. As long as it is the popular view that the price of coal is made up of one part each of mining costs and freight costs to two parts each of operator's profits and railroad dividends, with the cost of a certain amount of needless waste on the side, the demand for investigation will continue, and in so far as there is any element of truth in this view, legislative action is justified, even though the prescribed reform may approach the extreme of public ownership and operation of mines and railroads.

As the initial item of cost, the amount charged against the marketed product as the value of the coal in the ground, which for brevity may be termed the resource cost, is perhaps the item most often overlooked by the coal consumer, and for this reason that phase of the subject will be fully considered after the other items are treated. These other items need less discussion in this paper for several reasons: the item of marketing cost is one that can be brought directly under observation by the consumer if he will but study the matter intelligently, the transportation cost can be learned by simple inquiry and its control lies within the province of the Interstate Commerce Commission, and the details of mining cost can best be set forth by the mine operators themselves, for they have now adopted the policy of free discussion of these matters, which they once regarded as sacred from public view. The purpose of this paper, then, is simply to give a summary statement of all these elements in the cost of coal, and some special discussion of the resource cost. In presenting the subject, the senior author assumes responsibility for whatever may be regarded as mere expressions of opinion and the junior author stands behind the statements of fact.

MINING COST

The item of cost first to be considered represents that part of the value given to the ton of coal by the mine operator and the mine worker. This may be termed mining cost, but it must include the operator's selling costs and other overhead expenses as well as the mining costs proper which include the larger expenditures for wages, supplies, and power. This cost plus the resource cost—the royalty or depletion charge—and the profit or loss on the sale make up the value at the mine mouth. The mining cost varies not only between mines of different companies in separated fields but even between adjacent mines of the same company in the same field. Both nature and man contribute to such variation.

It is not practicable to assign a very exact figure to the mining cost—the census of 1909 indicated an average of \$1 a ton for bituminous coal and \$1.86 for anthracite, but these figures are believed by some operators to be too low. It is possible, however, to show in a general way the distribution of this item; the cost of

*A paper read before the American Mining Congress at Chicago on November 14, 1916.

mining is divided between labor, 70 to 75 per cent; materials, 16 to 20 per cent; general expense at mine and office and insurance, 2 to 4 per cent; taxes less than 1 per cent to 3 per cent for bituminous coal, and 3 to 7 per cent for anthracite; selling expenses nothing to 5 per cent, and recently to these items has been added the direct and indirect cost of workman's compensation which may reach 5 per cent for bituminous coal. The charges for labor, material, and general office expenses are easily understood, as is also a charge for depreciation of plant and machinery; but taxes and selling expenses are important items that may be overlooked by the casual observer. Some figures recently published show that the taxes levied in West Virginia last year on coal lands and coal-mine improvements—that is, on the industry as a whole—were equivalent to nearly 3 cents per net ton of coal produced, which is doubtless fully as much as the profit made by many of the operators in that State.

The cost of selling coal is nothing for the companies that use their own product, including the Steel Corporation and a large number of others, and is little or nothing for the producers who sell nearly all their coal to such large consumers as the railroads. Companies that produce coal for domestic use and the general run of steam trade must figure on a selling cost as high as 10 cents or more per ton, the cost depending on the extent of their business. The average selling cost for bituminous coal is probably 5 to 10 cents a ton, and for anthracite the usual charge of sales agencies is reported as 10 cents a ton for steam sizes and 15 cents for the prepared sizes.

TRANSPORTATION COST

The producers of coal and the transportation companies are concerned not so much with the actual rates charged for carrying coal as with the adjustment of rates between different coal fields and between different markets. In the many years in which our coal industry has been developing, rate structures have been built up that give to this and that producing district differentials over other districts—"handicaps," as it were—that may be based on comparative lengths of haul or on the ability of the coals to compete by reason of difference in quality or in cost of mining, or perhaps may be merely the survival of past practice, for which no reason now exists. The consumer of coal, however, is interested in the actual rather than the relative freight rate.

To help toward a realization of the magnitude of this transportation item, it may be pointed out, first, that all but 14 per cent of the output of the country's coal mines, aggregating 532,000,000 tons, is moved to market by rail or water, and second, that nearly half of the bituminous coal (47 per cent in 1915) and more than two-thirds of the anthracite (71 per cent in 1915) is shipped outside of the States in which it is produced.

Add to this statement of the extent to which coal enters interstate commerce, a glance at the distribution of centers of maximum production and maximum consumption—the New York-Baltimore industrial zone, which has a total per capita consumption of nearly 10 tons and lies 100 to 400 miles from the tributary coal fields; New England, consuming about 7 tons to the unit of population and lying 400 to 800 miles from its coal supply; or the populous industrial district of which Chicago is the commercial center, consuming 8 to 9 tons per capita of coal in part hauled more than 400 miles from the fields of West Virginia and eastern Kentucky and in part 200 miles or less from the Illinois mines. With these facts in mind we must realize that the transportation cost is necessarily a large part of the country's fuel bill.

As has already been suggested, the transportation rate in force from any coal field to any market can readily be learned by the consumer who wishes to figure this item in the cost of the coal which he buys. There fore in the present general consideration of the subject it is sufficient to state the average value of this item. In the interstate traffic, both rail and water, bituminous coal probably pays an average freight of nearly \$2 per ton. In other words, the transportation costs more than the product and, as some parts of the country are just now learning, is sometimes more difficult to obtain. The value of coal, like the value of so many other commodities, is a place value.

The average freight charge on anthracite is higher than that on bituminous coal, first because the rates are higher and second because according to the reports of the Interstate Commerce Commission, *all* movements considered, the coal is carried a greater distance.

MARKETING COST

The cost of handling the coal, exclusive of freight, from the time it leaves the producer until it is in the consumer's fuel bin, may be termed the marketing cost. It can readily be seen that a large part of the coal produced is not subject to this cost, for most large users of steam coal, such as the railroads and the coke manufacturers, place contracts directly with the producing companies or their selling agencies and buy in the open market only when their needs exceed the deliveries under their contracts. Much of the coal, however, both anthracite and bituminous, passes through the hands of a wholesale dealer or jobber before it is received by the retail dealer who puts it in our cellars or in the bins of a power plant. Coal that gets a long way from the mine may pass through many hands before it reaches the consumer, and it not only pays commissions all along the line but is subject to shrinkage and deterioration, both of which enter into the final selling price to the consumer. Brokers are usually satisfied to make a gross profit of perhaps 10 cents a ton, but as several brokers may make a "turn over" on the same car before it is unloaded this element of cost may be several times that amount.

About half of the anthracite and around 15 per cent of the bituminous coal is retailed in less than carload lots, and the greatest number of individuals are directly concerned in the marketing of this portion, regarding the profits on which there is the widest divergence of opinion. The margin in the retail business between cost on cars and price delivered is between \$1.25 and \$2 a ton and is not more than enough to give on the average a fair profit. The shrinkage and, in part, the deterioration are together seldom less than 1 per cent of the weight and may exceed 4 per cent, and the retail dealer also must provide in his selling price for uncollectible accounts.

Advertising is a large expense—in part carried by the retailer directly but all borne by the industry. The largest single item in the cost of retailing is of course that representing the labor of handling and the local cartage, which together make up about half the marketing cost.

RESOURCE COST

There now remains to be considered the first major item, or the resource cost, which is what the operator has to pay for the coal in the ground—the idle resource, which he starts on its career of usefulness. This cost is expressed as a royalty or a depletion charge.

One of the latest leases by a large coal-land owner provides for the payment of 27 per cent of the selling price of the coal at the breaker. This percentage is

therefore not only a royalty figured on the mineral resource but also a commission based on the miner's wage. To bring this right home to you and to me, it may be said that the practical result is that if the anthracite we burn in our range this winter happens to come from that particular property, we will pay fully \$1 a ton into the treasury of the city trust that owes its existence to the far-seeing business sense of a hard-headed citizen of Philadelphia. Whether such a royalty is excessive or not the fact remains that this is the tribute paid to private ownership.

The present average rate of royalty on anthracite is probably between 32 and 35 cents a ton on all sizes, which is from 12 to 14 per cent of the selling value at the mine. The minimum rate (about 10 per cent) is found in some old leases, and the maximum (20 to 27 per cent) in leases made in the last five years. R. V. Norris states that in the late sixties, when the annual output of anthracite was around 15,000,000 tons, royalties were 8 to 10 cents a ton on prepared sizes, but that no charge was made on the smaller sizes. In the seventies the rate rose to 25 cents on prepared, one-half that on pea, and one-fourth on smaller sizes. By the middle eighties, when the output was a third what it is now, the rate was about double that of the seventies—that is, 40 to 50 cents on the larger sizes and 5 to 10 cents on the smaller sizes. The tendency is still upward by reason of increases in the rates for intermediate sizes and the operation of royalty rates based on a percentage of the selling value, an increasing quantity. Figured on the output from the Girard lands, which is nearly 3 per cent of the total production, the gross return to the estate from its coal lands is over 50 cents a ton.

Nor is the increase in value of anthracite lands any less striking. At the beginning of the last century, as stated by Mr. Norris, the great bulk of these lands were patented by the State of Pennsylvania for \$2 to \$4 an acre; in the middle of the century the price of the best land rose to \$50, and in 1875 even to \$500. Now \$3,000 an acre has been paid for virgin coal land, and little is on the market at that. In considering these increases in land values, the effect of interest and taxes must not be overlooked.

The bituminous coal industry is a modern institution compared with the mining of anthracite, and much of the bituminous coal land was acquired by the operating companies during the last twenty years for little if anything more than its surface value. To-day there are large areas of bituminous coal-bearing lands that, because they are undeveloped and without railroads, can be purchased at a low price, but little or no anthracite land is on the market, and little has changed hands for years. The present average resource cost of bituminous coal is not much over 5 cents a ton, or about 4 per cent of the average selling value at the mine. In the Pocahontas region and the Pittsburgh district the royalties are much higher, but these like others that might be cited, are exceptions—one due to coal of special quality, and the other to location—factors which, incidentally, are exactly those that have assisted in making the resource cost of anthracite what it is.

Should you be interested in summing up all these various costs and striking a balance between labor's share and capital's return, you would find that the mine worker, the trainman, and the wagon driver together receive fully half of the price of the anthracite delivered at your house, and the same three classes of labor receive not less than half the price paid by the average consumer for the cheaper soft coal. In a similar manner the average return on the capital invested in land, mining plant, railroads, and coal yard may be roughly cal-

culated, with the result that landlord, bondholder and stockholder of coal company and railroad together receive about \$1.15 from the ton of anthracite and only 50 to 75 cents from the ton of bituminous coal, and of either of these amounts the mine operator's share is only a small fraction.

POSSIBILITIES OF RELIEF

It is not the purpose of this analysis of costs to offer any cure-all for the high price of coal, yet some comment on the facts presented may possess value. At least certain lines of approach can be pointed out as not very promising. For example, anyone who is at all cognizant of the trend in price of labor and material can see little hope of relief in lower costs for these items. Furthermore, observation of the advances made in mining methods in the last decade or two affords slight warrant for belief in any change of wasteful operation. As consumers of coal we might do well to imitate the economy now enforced by the producers in their engineering practice. In the Northern anthracite field machine mining is extracting coal from 22 and 24-in. beds, and throughout the anthracite region the average recovery of coal in mining is 65 per cent, as against 40 per cent only twenty years ago. Nor are the bituminous operators any less progressive in their conservation of the coal they mine.

Yet it must be remembered that conservation of a natural resource, though it will undoubtedly be of direct economic benefit in the future, is not essentially a cheapening process; in fact, these increased recoveries of coal have in large part become possible only because of a higher market price. And, following further this line of thought, we may say that the increased safety in the coal mines that has come through the combined efforts of the coal companies, the State inspectors, and the Federal Bureau of Mines necessarily involves some increase in cost of operation, but the few cents per ton thus added to the cost is a small price to pay for the satisfaction of having the stain of blood removed from the coal we buy. That form of social insurance which is now enforced through the workman's compensation laws alone adds from 2 to 5 cents a ton to the cost of coal.

In the item of transportation perhaps the most promising means of relief is that of reducing the length of haul. Though many a consumer's preference for coal from a distant field over that from a field nearer home is based on special requirements, the deciding element in the preference of other consumers is simply the price, and this in turn may be largely due to a differential freight scale, which is thus not in the public interest if we admit the premise that it is wasteful to burn coal in hauling coal into coal districts or past such districts, except in so far as quality requirements absolutely demand the long-haul coal. The recent eastward movement of the higher-grade coals, in part caused by the export demand, may involve some increase in the average length of haul, and thus in the transportation cost of coal not exported, but on the other hand this enforced adjustment may lead some consumers to discover nearer home sources of coal equally well suited to their purposes.

Reduction in marketing costs is a reform so close to the consumer that he should be able to find for himself whatever relief is possible. Professor Mead of the University of Pennsylvania is authority for the statement that the delivery of coal is costing the dealers 50 cents a ton more than is necessary.

There only remains, therefore, the first item of all—the value of the coal in the ground, or rather the return which the landowner is asking for this natural

resource. The fortunate holder of coal land, whether a very human individual or a soulless corporation or a large trust estate administered for benevolence only, is likely to endeavor to get all that the traffic will bear. Especially in the possession of a limited resource like anthracite, the tendency has been and will continue to be to increase royalties as the years pass, and the only penalty imposed by the State for high royalties seems to be high taxes, which too often, indeed, serve to justify the high resource cost put upon coal in the ground. Finally, in considering royalty rates or depletion charge we must not overlook the interest that accumulates throughout the period between the purchase of the coal land and the removal of the last ton of coal.

In placing a value upon the Choctaw lands some years ago the Geological Survey figured the aggregate royalties at current rates as \$160,000,000, but if that amount of royalty were to be collected through the six or seven centuries required for mining the 2,000,000,000 tons under this land, the present value of the land would be only \$6,500,000 if purchased by the Federal Government or only \$4,000,000 if purchased by the State of Oklahoma, and even less if the project were financed by a corporation that would need to issue 6 per cent bonds. Such is an illustration from actual experience in coal-land valuation—the \$4,000,000 to \$6,000,000 invested in these Oklahoma coal lands now would require a final return of \$160,000,000 in royalties to balance the account.

More recently Mr. Cushing, the editor of *Black Diamond*, has figured the cost of a monopolistic control of the available coal resources east of the Rocky Mountains on the basis of the United States Geological Survey estimate of two million million tons. At a valuation of coal in the ground of only 1 cent a ton, which, as he stated, is less than has been paid for large holdings, this deal would require a capitalization of \$20,000,000,000, and the fixed charges on the bonds of this United States Coal Corporation would require an interest charge alone of \$2 a ton against a production of 600,000,000 tons a year. Mr. Cushing characterizes such a financial undertaking in mild terms as hopelessly impossible, and yet his figures, which do not include taxes, are most enlightening as affording some measure of the cost of possessing an undeveloped resource. Incidentally, these startling figures furnish a strong argument for the present policy of the National Government in retaining ownership of the public coal lands, at least up to the time when the market conditions justify the opening of a mine and then either leasing or selling a tract only large enough for that operation. The consumer of the next century simply cannot afford to have private capitalists invest to-day in coal land for their great grandchildren to lease.

The burden that seems inevitable under unregulated private ownership of a natural resource like coal is that because the lands containing these national reserves of heat and power are taxed and because the individual or corporation properly charges up interest at current rates on his large holding, the consumer must pay a resource cost which takes into account the long period of undevelopment. Even the high rates of royalty on the lands of the Girard Estate may be found less excessive than they seem if a century's taxes and interest charges are figured. Yet the fact remains that the royalty for anthracite represents a much larger proportion of the cost of the mined coal than any bituminous royalties. Moreover, we believe the highest royalty prevailing in the anthracite region has far more influence in fixing the selling price than the lower rates of the older leases.

Any study of costs in the coal industry finds its point

in the question, not who but what fixes the price of coal. The cost of mining coal, like the cost of living, is increasing. Exact mining costs, however, cannot be determined until the operatives have accomplished their reform of standardizing accounting. Too often the operator includes in his account only the two largest and most obvious items, labor and material. Thus, when the market for bituminous coal is dull, the company whose land costs little or nothing is able to set a lower limit of price than the company whose coal must stand a charge of 5 to 10 cents per ton or even more, be that charge called royalty, depletion, or amortization. At such times the operator with the larger resource cost must sell at a real though not always recognized loss, but, of course, with the hope of recouping himself at times of high prices like the present, if fortunately he has any coal to sell not already contracted for.

Even with the average low resource cost of bituminous coal, the state of competition that is tied up with idle and half-worked mines results in an average total cost that is little below the average selling price. Of course, in this business there are those, both large operators and small, who make a profit in lean as well as in fat years, just as there are those for whom the prosperous years are too infrequent to keep them out of the hands of receivers.

In the anthracite fields the mining costs, and especially the resource costs, are higher. But here, with an average market demand that normally exceeds or at least equals the available supply (and with the passing years this disparity must be expected to increase), there results naturally a lack of competition for the market. Even gentlemen's agreements are unnecessary as long as every operator can reasonably expect to sell his product, and the market price of anthracite at the mine must, therefore, tend to be fixed by the operator who has the largest mining and resource cost rather than by his neighbor who may be doubly favored with a mine less expensive to work and a lease less exacting in terms.

Confessedly, this analysis of the cost elements that enter into the price of coal emphasizes our lack of specific facts, which can be supplied in the future only through "installation of uniform cost-keeping methods and uniform and improved accounting systems," to quote from the declaration of purposes of the Pittsburgh coal producers. With the results of such book-keeping in hand, more definite reply can be made to the public's appeal for relief from high prices. Yet even now it may be possible to suggest how that relief will eventually be obtained. Study of present conditions in the coal mining districts fails to encourage the idea of governmental operation of the 7,000 coal mines in this country. More in line with the trend of public sentiment in the last decade, however, is governmental control in the interest of the consumer by regulation of prices, and to judge from the facts of experience in the regulation of transportation of other public utilities, the public coal commissions will be given sufficient discretionary powers to safeguard the interests of producer and consumer alike, and even mandatory requirements, either legislative or executive, will be subject to judicial review.

Competition seems to have failed of late years to benefit the consumer of coal. In the bituminous fields the competition whenever present has been wasteful, and in the anthracite fields there has been practical absence of healthy competition, and whether too great or too little competition, the result is the same—to increase the actual cost of bituminous coal by saddling the industry and its product with the fixed charges on idle or semi-idle mines, and to raise the price of anthra-

cite coal by favoring the burdens of high resource costs.

In estimating the aggregate losses incurred by society by reason of the large number of mines not working at full capacity, the facts to be considered are that the capital invested in mine equipment asks a wage based on a year of 365 days of twenty-four hours, while labor's year averaged last year only 230 days in the anthracite mines and only 203 days in the bituminous mines with only five to eight hours to the day.

As coal is more an interstate than intrastate commodity, any regulation of prices needs to be under federal control, and to benefit both consumer and producer such control cannot stop with transportation and mining costs, but must stand ready to exercise full rights as a trustee of the people over the coal in the ground. The private owner of coal land, which derives its real value from society's needs, has no more sacred right to decide whether or not that coal shall be mined when it is needed by society or to fix an exorbitant price on this indispensable national resource than the coal operators have to combine for the purpose of exacting an excessive profit from the consumer, or the railroads to charge all that the traffic may bear. The proposal to bring landowner under the same rule as mine operator and coal carrier may seem radical, but where is the point at which coal becomes the resource upon which industrial society depends for its very life?

Public regulation, however, will be fair, and, indeed, in the long run will prove beneficial to the landowner as well as to the consumer, to the mine worker as well as to the operator, because any such agency as the Federal Trade Commission, in its control of prices, must determine costs; and as we interpret the present attitude of the whole coal-mining industry, the operators are willing to rest their case on a fair determination of actual costs on which their profits may then be figured.

U. S. Geological Survey,
Washington, D. C.

Recent Development in Incandescent Gas Mantles*

By E. L. Knoedler

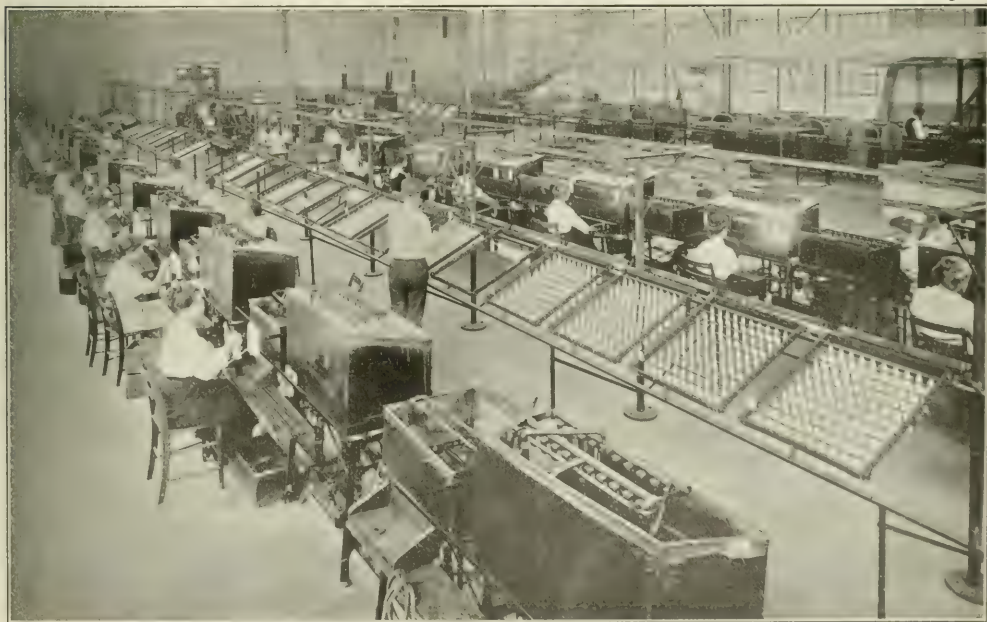
Much has been said and written about the process of manufacture of gas mantles, so much, in fact, that I have feared the possibility of presenting much matter that is already familiar to you.

The flexible mantle or rag mantle is not new to those who are acquainted either with pressure gas or with pressure gasoline lighting. To be sure, pressure-gas lighting has been very slow in developing in the United States, but in Europe it finds wide and successful application. On the other hand, gasoline pressure lamps using rag mantles are very numerous and popular in this country, particularly in the great Northwest.

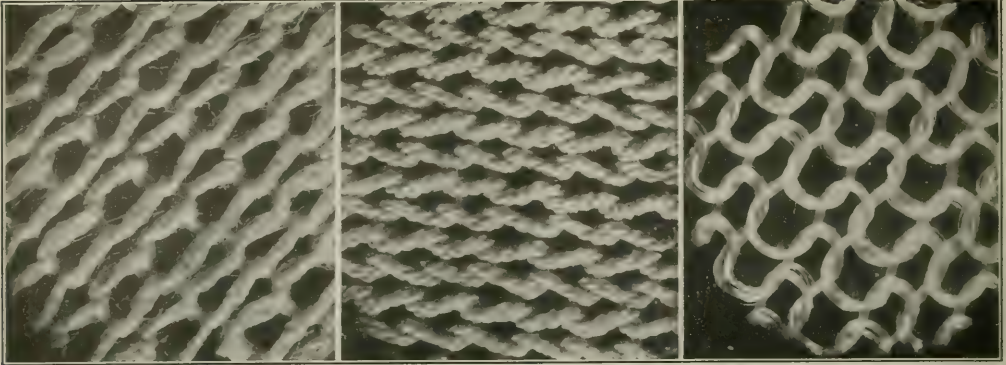
From time to time statements have been made and lurid advertisements have appeared, announcing successful flexible mantles for use on ordinary gas burners, but as a matter of fact these statements have been largely those of fakirs, whose wares have been advertised and exploited as "unbreakable mantles." During the past few years, first one, then another, of these mantles has appeared, only to disappear again as does every article which fails to impress the consuming public as measuring up to the claims made for it.

An important point in connection with the use of a flexible mantle is the fact that the mantle is only partially manufactured. The customer purchases an unfinished article and assumes the risk of carrying out successfully that part of the technical manufacturing process which the maker of the goods has permitted him to assume. These risks of damage and loss vary inversely as the quality of the article. In order to be successful and satisfactory, the advantages of using a

*A paper presented at the joint meeting of the New York Section of the American Electrochemical Society and the Illuminating Engineering Society on Nov. 9, 1916.



THE BURNING AND HARDENING OF THE UPRIGHT TYPE GAS MANTLES



RAMIE MANTLE FABRIC. NOTE PARTICULARLY THE IRREGULARITY OF FIBERS AND FABRIC

COTTON MANTLE FABRIC. NOTICE ABSENCE OF INDIVIDUAL FIBERS

ARTIFICIAL SILK MANTLE FABRIC. NOTE THE SMOOTH, PLIABLE, UNIFORM FIBERS

flexible mantle must outweigh the disadvantage and the trouble to which the customer is put, when he is compelled to perform the later manufacturing operations himself, at the time of putting the mantle into service.

Now, these much advertised "unbreakable" mantles, of which I have made mention, have been without exception the very cheapest and flimsiest which could be made and still hold together until in place on the burner. No other construction would permit of sufficient expansion by the flame of the ordinary gas burner to produce even the remotest resemblance to a gas mantle.

The use of medium-grade, or more often of low-grade cotton or ramie threads, impregnated with only the smallest possible quantity of thoria, has resulted in such a weakened structure that the mantles soon fell to pieces.

Again, as a rule, the shape of these mantles has not been favorable to the production of maximum candle-power.

Finally, if the shape of the mantle was satisfactory, and if by chance it was able to remain in service for any length of time, the candle-power was found to deteriorate very quickly and the color to change from yellow to greenish white, after burning only a relatively short time. These changes were due in large measure to the poor quality of the base or to the small quantity of light-producing materials present.

In the case of the new mantle of which I shall speak, the shaping or hardening process has been greatly simplified, and the use of an improved base material has almost entirely eliminated the danger to the consumer of a manufacturing loss. This new mantle is unique in a number of ways, but its success depends primarily upon two things: First, upon the fact that it can be

used only upon a burner designed and constructed for this particular mantle. Second, upon the construction of the mantle itself and the character of the materials used in its manufacture.

In connection with the question of the burner I shall only stop to say that the design is such as to produce a perfect gas and air mixture, with any gas at the gas pressures ordinarily available; a mixture which is uniform and which does not contain the lean and fat streaks so often present in gas mixtures provided by the average burner. The flame produced by this burner is very hot, containing more primary air than usual and therefore requiring less secondary air for complete combustion. This makes for perfect combustion with almost complete absence of the tendency to carbonize. This burner has a wide operating range and will permit of considerable over and under adjustment.



KNITTING MANTLE FABRICS

*Comparative Physical Strength
of Upright Mantles*

	Shock Strength	Tensile Strength
Art Silk	— 1000 bumps	— 2000 CC
6 Ply Cotton	— 427 bumps	— 3200 C
Ramie	— 250 bumps	— 3210 C
2 Ply Cotton	— 81 bumps	— 2500 C

* Mantles not subject to more than 1000 bumps



THE SEWING AND INSPECTING OF GAS MANTLES

It will likewise continue to operate satisfactorily when the gas pressures vary so as to seriously affect the majority of other gas lighting burners.

The mantle itself is unique in many ways.

In the first place, it is made from artificial fiber, popularly known as artificial silk.

In the second place, it is small in size, being only $\frac{7}{8}$ in. in length and $\frac{1}{4}$ in. in diameter.

Finally it is of the totally closed variety, having no vent at the top, as have all the older types of both upright and inverted mantles.

First we will consider the material from which the mantle fabric is woven.

Artificial fibers are made by treating cotton or other cellulose fibers in such a way as to convert them into a thick viscous liquid which is forced, under high pressure, through fine dies, into a solution which fixes the thin wire-like strands thus formed.

There are several satisfactory methods for making these artificial fibers, but the best product from the

standpoint of the mantle industry is made by the viscose process.

These fine artificial threads have important advantages over natural fibers, for mantle-making purposes.

In the first place, the physical and chemical properties are almost completely under control, so that fabrics made from artificial threads are incomparably more uniform in their essential physical and chemical features than are those made from the natural fibers.

Again, the artificial thread used, while thin, is very strong and is capable of substantially heavier impregnation than either cotton or ramie threads, which makes for great physical strength and elasticity.

Cotton fiber varies from 1 in. to $1\frac{1}{2}$ in. in length, and is tubular in form.

Ramie fiber, also largely used in the manufacture of mantles, is several inches in length and flattened or husk shaped.

Both of these fibers are more or less hollow, and are



BURNING AND HARDENING INVERTED TYPE GAS MANTLES

often distorted in shape, broken, or otherwise imperfect.

Contrast with these the artificial fiber, of almost infinite length, solid like a wire, uniform in cross section, and of predetermined diameter, in fact made to suit the purpose to which it is to be put, and it is easy to see why there should be a difference in the finished products made from such different raw materials.

Again, the chemical properties of the fibers are of utmost importance in connection with the quality of the goods. The chemical constituents of the natural fibers vary with the different staples, with the character of the ground upon which they grow and with the methods of working in the various mills where the threads are spun and bleached.

These variations render necessary very comprehensive bleaching and washing processes in order that the chemical differences may be so leveled down as to produce a uniform product.

In the case of the artificial fiber many of the chemical impurities have been removed during the manufacturing process, and those which remain have been uniformly distributed throughout the whole batch of material so that all the fibers are of identically the same chemical composition.

In one case we have to work with the natural fibers as nature gives them to us, in the other we deal with a material which can be so fashioned by a controllable manufacturing process as to give us exactly the kind of material we require.

In considering the bearing of these facts, it must be born in mind that the process of manufacture of any gas mantle is essentially that of replacing the fiber with the salts of the rare earths and that the mantle is therefore an exact reproduction in rare earth oxides of what the fiber was.

With these facts in mind, let us examine mantles made from these various natural and artificial fibers, and compare their characteristics.

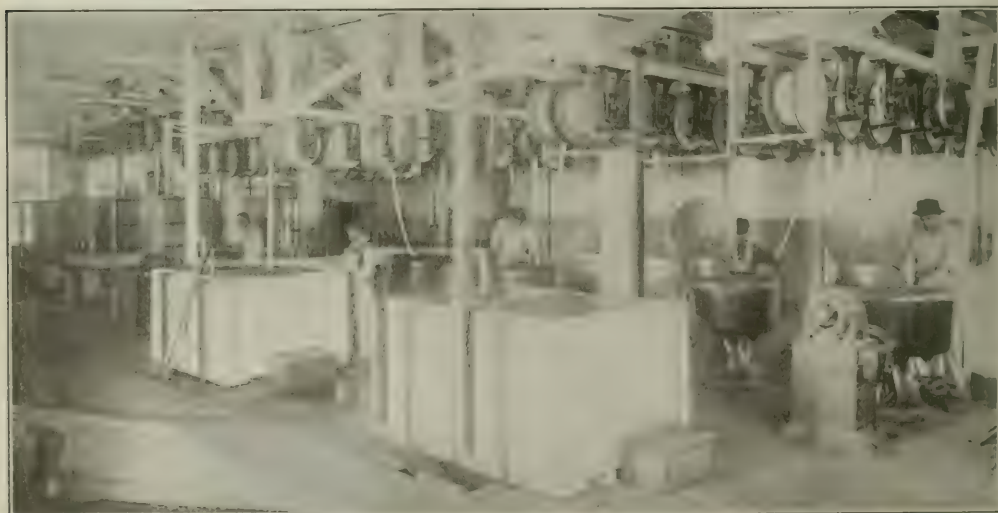
The Cotton Mantle. Soft and flexible initially, after a few hours of burning it will be observed that the mantle is growing hard and brittle. This condition is exaggerated as the period of service lengthens out.

After some time the mantle becomes very hard and is rather easily broken by shock. This change in temper is accompanied by a shrinkage in size, which may reduce the area of the working surface as much as 10 per cent or 15 per cent in 100 hours. As the surface grows smaller, it grows proportionately denser, and less effective as a light-producing body. The openings between the meshes of the mantle structure are reduced in size and the discharge of the products of combustion through the mantle becomes increasingly difficult. Gradually the air inflow is throttled and combustion becomes less and less perfect, resulting finally in the worst cases in carbonization and breakage of the mantle. In any case, these changes in the cotton mantle produce a substantial drop in the candle-power during the first 50 or 100 hours of service, with a further slow but certain reduction as the mantle continues in use.

Finally, not only has the amount of light been considerably reduced, but the color of the light has changed from an agreeable mellow color to a greenish white. These phenomena take place in every cotton mantle in a shorter or longer period of time, but they proceed with special rapidity in a mantle which has been skimped during manufacture either by the use of inferior cotton, or by improper density of impregnation.

The Ramie Mantle. Ramie mantles are initially flexible, like cotton mantles, although somewhat harder in texture. Like cotton mantles, they also change on burning, from a flexible structure to one which is hard and brittle. If anything, the ramie mantle becomes more brittle and less able to withstand the shocks to which it is subjected in service, than does the cotton mantle. While in the matter of physical strength the ramie mantle is thus much like its predecessor the cotton mantle, in the matter of shrinkage it is greatly superior. For this reason it has become very popular when made in the inverted style. On this type of burner shrinkage of the mantle is a particularly serious matter, as small derangements in adjustment are likely to cause carbonization and mantle breakage.

The candle-power life of the ramie mantle, like the shrinkage, shows great improvement over the cotton mantle, but the results are not all that are desired.



WASHING DEPARTMENT, WHERE THE THREADS ARE CLEANSSED OF THEIR IMPURITIES BEFORE BEING MADE INTO GAS MANTLES

It is characteristic of both these mantles that the fine filaments which cover their working surfaces pick up and hold the mineral dust which is drawn into the burner with the air supply. This dusting of the incandescent filaments with siliceous matter probably contributes materially in hastening the depreciation of the mantles.

The color of the ramie mantle also changes slowly as the mantle continues in service.

The Artificial Fiber Mantle. Artificial fiber mantles in service appear to undergo no change in physical condition, maintaining their strength and elasticity over long periods of time. They never become hard and brittle and their ability to withstand shocks after a long life of service seems to be almost as great as it was initially.

The physical strength of these artificial mantles is surprising; they will withstand many times the amount of rough treatment required to destroy the best cotton or ramie mantle. They do not shrink in the slightest degree even after many hundreds of hours in use, but remain perfect in shape, and adapted to the flames to which they have been adjusted.

One of the most remarkable features about the artificial silk mantle is the fact that during the first few hundred hours the candle-power actually shows an increase, which often amounts to 5 or 6 per cent; following this there is a very slow depreciation of candle-power, but even after 1000 hours of service it will usually be found that the mantle is giving as much light as it gave in its initial test.

The color of the light given by silk mantles is likewise very stable in its quality, the change in color being almost imperceptible even after long periods of use.

These several features so favorable to the use of artificial silk in the manufacture of gas mantles, have made possible the development of a successful limp or rag mantle.

We have observed that light weight is necessary if the limp mantle is to be properly shaped on the low pressure gas burner, but light weight in a gas mantle is not compatible with either strength or sustained candle-power. Here artificial silk supplies the deficiencies. These fibers, even though made very fine and light, are yet, by the nature of their structure, able to impart great strength to the mantle. The use of many such very fine fibers gives a working surface of large area, hence high candle-power. Sustained candle-power and the absence of shrinkage complete the list of features necessary to a high grade and successful article.

Up to the present time it has been found most practicable to make this new mantle in a relatively small size, and to so construct the burner that it takes three mantles instead of one. This has several important advantages, one of which is the fact that the small mantle is light in weight and small in area and, therefore, much stronger proportionately than it would be if of larger size. The shortening of the mantle greatly reduces the liability of breakage around the ring, as it not only reduces the load carried by that part of the mantle which is tied fast to the ring, but it also minimizes the tendency of the mantle to whip off from its solid fastening.

The proper shaping of this mantle on the burner takes place with greater certainty than it would if the mantle were of larger size. This point will be seen to be of importance, when it is remembered that the shaping is not carried out in the factory at the hands of an expert, but that every customer must do this work for himself.

The maintenance man who must carry and handle

large numbers of mantles in the course of a day's work will especially welcome this change in size.

The use of three mantles on a burner instead of one has the advantage that if one mantle is broken the lamp does not go out of commission, but still continues to give a large amount of light.

As we observed before, this mantle is of the totally closed variety, there being no vent at the top through which a portion of the gases may escape. All the burning gases must pass through the mantle and be effectively utilized in the production of light. The mantle holder itself is threaded and screws tightly on to the burner nozzle, an advantage where there is vibration.

These new mantles are uniformly and brilliantly illuminated over their entire surface, even in the zone immediately adjacent to the mantle ring. Their intrinsic brilliancy is higher than that of any low-pressure mantle heretofore developed and from the results so far tabulated their useful life appears to be greater than that of any other gas mantle in common use to-day.

Some Notes on Gas Standards*

By W. R. Addicks

Vice-president Consolidated Gas Co.

The title of my remarks might more appropriately read, "Some Notes on Gas Standards and Their Influence on the Prosperity of the Gas Industry."

At no time in the history of the gas industry has the business future of this important public service commodity seemed so bright as now.

The most important requirement for good gas service is *uniform quality*. For reasons that will appear this is becoming possible through the introduction of the heat-unit standard for gas quality. Taking as a basis gas made by carbonization of bituminous coal, that is, coal gas, we have available two diluents, first water gas having about 325 heat units per cubic foot, and second, oil gas with about 1200 heat units per cubic foot. With these two sources available for equalizers, coal gas, whether made by the coke oven process or by the retort process, either horizontal, inclined or vertical systems, may be successfully controlled in spite of the tremendous variations in demand due to atmospheric and seasonal causes, as well as because of the range of sales due to occupational conditions on Sundays, weekdays and holidays. In large companies the variation in output from day to day may frequently reach 10,000,000 cu. ft., or an amount equal to the maximum daily demand of a city of several hundred thousand inhabitants, as, for instance, the city of Boston, excluding its suburbs.

The next most important requirement for good gas service is *constant pressure*. This does not necessitate uniform pressure in all areas. It is only necessary that the changes in pressure in any one locality shall not have too wide a range, the amount of pressure at any point not being the essential element. Here again a heat-unit standard for quality is of great service, for high-pressure mains may be introduced, where desirable, that will effect this pressure equalization without material deterioration in heat-unit gas quality. In suburban communities high pressure is now common in the house services of the distribution system; house governors reduce the initial pressure to any required point, and escape pipes are installed to provide for any derangement of the governor. A high-pressure system is impossible under a candle-power requirement for quality.

*A paper read at the joint meeting of the New York Sections of the American Electrochemical Society and the Illuminating Engineering Society on Nov. 9, 1916.

In addition to standards for gas quality and pressure of distribution, we have standards for purity relating to sulphuretted hydrogen, fixed sulphur compounds and ammonia, and standards for accuracy in metered service.

It is not proposed to go into any historical outline of the progress of the gas industry or to trace the successive regulatory requirements for gas distribution, but it is appropriate to cite some inventions during the past 100 years or more that have rendered possible the present prosperous conditions in the gas industry. Some of these are the hydraulic seal; the steam boiler and engine; the gas exhauster; the gas holder (formerly known as the gasometer); the gas meter; the photometer; the gas cooking range; the internal combustion engine; the many types of industrial appliances; the fireclay retort, which displaced the cast-iron retort, thus enabling the manufacturer to increase the gas yields from coal, and the later highly refractory silicate materials for both retorts and settings, which permit still further increase in gas yields per pound of coal; apparatus for gas analysis, readily operated by others than chemists; the calorimeter and surface combustion.

There have appeared from time to time epoch-making influences in the history of the gas industry since 1792, when Murdoch introduced gas for lighting. Some have been apparent at the time, while others are appreciated only after a lapse of years, during which their influence has been at work.

The introduction of cast-iron pipe about 1808 for distribution purposes greatly aided in making the gas industry permanently successful. Cast-iron mains seldom require renewal except because of obsolescence due to existing mains being too small for the demands of modern industry.

The use of regenerative methods of heating gas retorts by Siemens about 1862 resulted in a material advance in manufacturing methods.

The successful carburization of blue water gas by Professor Lowe and his contemporaries about 1875 not only increased the use of gas because of low cost while oil was cheap, but made it possible to meet commercially the varying demands from day to day with plant costing less per unit capacity capable of operation to full capacity at an hour's notice with but a fraction of the idle labor coal gas manufacture then required, not withstanding the aid of large holder capacity.

The introduction of electric lighting about 1882, which at first frightened gas investors, later stimulated the gas manufacturer to make marked improvements in processes and methods of manufacture and utilization.

The introduction of the gas mantle burner about 1887, which saved the day for the gas companies by enabling them to hold their lighting business against electric competition while they were building up power and heating business more than offsetting their later losses in lighting due to the remarkable improvements in the efficiency of the incandescent electric lamp developed by the brilliant minds of this new and lusty competitor to the older industry.

The introduction of wrought-iron gas mains intended for high-pressure gas distribution was made by Flannery in 1889. The importance of this innovation was not at once grasped. Later steel pipes with screw or welded joints were adopted for pressure up to 100 lb. per square inch. Many communities now have a gas supply through this instrumentality that would never otherwise have had gas, for it is not possible to supply high-pressure gas under a candle-power standard.

The introduction of the automobile in 1891, where an internal combustion engine used gasoline for power, revolutionized the water-gas industry. All water-gas

plants habitually used gasoline and naphtha for enriching. These were entirely withdrawn from the market for this purpose, resulting in the abandonment of some gas plants that prior to this time were justly celebrated for the gas product produced. Fortunately the Lowe type of water-gas apparatus successfully utilized a lower-gravity petroleum, later known as gas oil, and this branch of the industry survived the crisis. Contemplation of this condition impels me to remark that this generation is using for its pleasures the necessities of future generations; it is to be hoped that the future generations may offset this serious condition by new inventions that will neutralize our prodigality.

The introduction in this country of by-product coke ovens in 1879 to 1893 has resulted in what may properly be styled by-product gas. In this coke process 5 to 12 or more tons of coal are heated with gas in an oven for eighteen to twenty-four hours, whereas in gas manufacture but 1000 lb. of coal is heated with coke in a gas retort for periods ranging from four to six hours. Probably in the future, producers using coke will supply the heat for coke ovens, in which case all the gas from the coal will be saved for other industrial uses in place of but 40 to 60 per cent as at present. As the success of the coke oven depends upon a uniform demand for coke in very large quantities, the gas, tar, and ammonia are by-products; coke ovens are not used by the gas manufacturer, for with him gas must be the chief product, and coke, tar, and ammonia by-products. Some gas companies purchase by-product gas for their general distribution, but they are compelled to maintain water-gas plants in order to supply immediately the gas demand when the coke oven plants are compelled to decrease their output because of dull coke markets or other reasons, climatic or commercial.

Continental Europe and Great Britain now have heat-unit standards for gas quality, and in the year 1915 the Dominion of Canada has followed Great Britain's lead. New Hampshire, New York (Second District after Jan. 1, 1917), Connecticut, Pennsylvania, New Jersey, Maryland, and the District of Columbia, and many other States of the Union are now using heat-unit standards for quality. At the last annual meeting of the American Gas Institute the following resolutions were adopted:

"Resolved, That the total heating value in manufactured gas best represents its quality for standard requirements, and

"Further Resolved, That the American Gas Institute recommends the adoption of the total heating value as the only standard basis of rating the quality of all manufactured gas distributed in the United States."

The Institute further adopted the following:

"Experience has demonstrated that in establishing any definite calorific standard for gas, the following are conditions that govern:

"1. In any calendar month gas should on the average at least meet the standard fixed.

"2. Except in case of accident or other incident of manufacture reasonably beyond control, the average of any day's determinations should not fall below the standard fixed by more than 10 per cent.

"3. Where gas is compressed the heating value shall be determined before compression.

"4. Gas should not be required to contain such percentages of constituents as to render the gas unstable under varying conditions of atmospheric temperatures and pressures.

"5. The standard adopted should not unnecessarily restrict the use of materials or processes to the detriment of economical manufacture or to prevent the conservation of natural resources.

"6. Materials and processes may be used whose by-products of manufacture are of military value to the Government."

In the future gas standards will undoubtedly provide for a total heating value, and absence of sulphuretted hydrogen and a limitation in distribution pressure variation at the meter. All fixed sulphur, ammonia, maximum and minimum distribution pressures and candle-power limitations will be abandoned as obsolete under modern conditions.

The adoption of a proper heat-unit standard improved measurably the strategic position which gas holds in the illuminating field. Distant control of the electric lamp has been the most important influence that has aided electricity to take the lead of gas in general illumination. Through the adoption of a heat-unit standard that no longer requires that gas contain constituents that tend to produce the deposition of carbon when burning will permit pilot lights and gas mantles, as well as water heaters and domestic utensils, to become more efficient due to greater ease in permanent regulation of gas combustion and a uniform cleanly condition, not depreciated by carbon deposit that climatic temperature changes surely bring about when the manufacturer is endeavoring to follow a candle-power standard. Candle-power standard gas, subject to severe atmospheric conditions, may lose in effectiveness 30 per cent where a heat-unit standard gas may not vary 2 per cent.

Where there is a gas supply and no central station electric service is available, it will be found very much easier and cheaper than formerly to obtain electric illumination through the use of the gas engine and electric generator. The gas engine is now a comparatively simple piece of machinery to a large number of persons, including many women and young men, because of their familiarity with automobile engines. The modern electric lamp of 50 cp. now requires but 50 watts of electric energy, whereas not many years ago it required four times that energy. A 5-brake-horse-power gas engine will now produce power for nearly seventy such lamps, while formerly a 20-hp. engine would have been required. The capital required for the installation and the difference in the yearly charges for gas, water, interest, depreciation and repairs of a 5-hp. engine when compared with a 20-hp. engine is very considerable. When using a 5-hp. engine no additional gas service would be required from the gas supply main, where the premises are already supplied with gas service. Should further improvement be made in electric lamp efficiencies, then more lamps, and hence a larger establishment, could be maintained with the same gas-engine equipment.

The gas mantle will always insure to the gas companies a large share of the illuminating business; as candles still continue to be used, so flat-flame burners will doubtless be used in cellars and furnace rooms; gas can be depended upon without the mantle burner for light sufficient for such purposes, but the use of the flat-flame burner for illuminating purposes with any gas is wasteful in the extreme. Great advance has been made in the adaptability of the mantle burner to the multitude of conditions that an illuminating burner must fulfill in these days. In this connection attention is directed to an article entitled "Gas Lighting in Industrial Plants," by Mr. Thomas Scofield, which appears in the *Engineering Magazine* for October, 1916. As gas pressures increase, the efficiency and general adaptability of the mantle burner will increase. As an illustration, I would recall to your mind the beautiful high-pressure lighting at the World's Fair in San Francisco in 1915.

It is most fortunate that the commercial conditions that make a heat-unit value for gas quality imperative should at the same time improve and simplify all problems of distribution and likewise that any increase in distribution pressures should under such a standard improve efficiency in the utilization of gas. These influences will doubtless be felt most beneficially in gas illumination through the use of the gas mantle. As hereinbefore stated, this invention has had a most important influence on the success of the gas industry in the illuminating field, and I believe it will hold its own against all competitors in the future.

Hollinger Consolidated Gold Mines Limited.—For four weeks ending Sept. 8, 1916, the milling costs of the Hollinger Consolidated Gold Mines, Ltd., was \$0.927 per ton. The mill ran 90.4 per cent of the possible running time, treating 50,177 tons. The average value of the ore treated was 8.59 per ton.

New Tannery in Norway.—A new establishment for the preparation of tanning extracts will be erected in the vicinity of Bergen, Norway, and will start operations in about one year. The name of the company is Den Norske Garveextractfabrik and is capitalized between \$200,000 and \$400,000.

Gold Production in British South Africa.—During the period from September, 1913, to January, 1916, the Transvaal production of gold was at the rate of \$194,660,000 per year. The average grade of ore treated was 8 cents lower, while the working costs increased from \$4.20 to \$4.28 per ton milled. In February last the milling cost rose to \$4.50 per ton. The working costs of the industry, amounting to \$121,662,500 remained largely in the country. Although the working profit per ton showed a decrease of 16 cents, the total working profit was higher than that for 1914 by \$1,006,251. The ratio of the Transvaal output to the world's total output for the year 1915 was 40 per cent, as compared to 38 per cent for 1914. The 1915 output represented 67 per cent of the gold production of the British Empire.

Extraction of Kauri Gum Oil in New Zealand.—In the northern part of New Zealand are found large beds of peat carrying fine kauri gum particles, and which are rich in materials producing kauri gum oil. It is claimed that the peat yields 20 to 30 gallons of oil per ton, of which about 25 per cent resembles gasoline or benzine. The remainder contains twenty-eight different kinds of heavy oils, several of which make good varnishing material. A company has been organized to extract from these peat beds the kauri gum and the kauri gum oils.

British Dyes, Ltd., held the first annual meeting at Huddersfield, England, on Oct. 12. The subscribed capital of the company and the loan capital to which they were entitled from the Government represented at the meeting held last year about \$7,350,000. At the close of the year ending April 30th, 1916, the capital had increased by about \$1,650,000, and at present the total capital is about \$9,600,000. One of the most important matters occupying the attention of the board was the supply of indigo. The only company producing indigo before the war was at Ellesmere Port, formerly owned by Meister, Lucius and Brünig. This plant was taken over by Messrs. Levinstein, Ltd., after the Board of Trade had decided not to let British Dyes, Ltd., bid for it. The chairman said that the company was devoting its main energies to the construction of plants and the carrying on of research necessary to manufacture the intermediates. A dividend of 6 per cent was ordered paid.

The Chemical and Physical Properties of Foundry Irons

By J. E. Johnson, Jr.

(Continued from page 597)

The Less Common Alloying Elements

CHROMIUM

The effect of chromium on iron and iron-carbon compounds has also been extensively investigated by Sir Robert Hadfield.¹ The effect of chromium is to harden the matrix of the iron, making an intensely hard but very brittle double carbide of chromium and iron. In low carbon alloys this makes a very strong, hard steel of low elongation. When the metal contains enough carbon to constitute cast iron, the tendency is to throw more and more of it into the combined condition, until, at 3.0 or 4.0 per cent chromium, the metal is entirely white, the fracture being flat, shining, highly polished plates, very similar to those in spiegel, and to those of weak iron carbon eutectic previously illustrated. (Compare Fig. 35, showing chromiferous iron, with Figs. 3 and 4, showing weak, high carbon, spotted iron.)

There is no doubt that chromium strengthens iron by throwing the carbon into the combined condition and by closing up its grain. It enables a hard chill to be secured, even in spite of the influence of a considerable percentage of silicon; but the structure consisting of these laminated plates has not the staying power of a chill produced by oxygen content without any other substance.

Fig. 36 shows a strong charcoal iron remelted in a crucible with sufficient chromium to raise the content of the remelt to 4 per cent. The structure to which I have alluded is strikingly shown. Test bars made from this mixture were strong, but not by 20 per cent as strong as test bars made from high oxygen iron without such a mixture. Chromiferous iron, particularly a

natural alloy made from certain ores, which contain chromium and nickel to the extent of about 2.5 and 1.25 per cent respectively, has been urged, in the past, as a substitute for the best grades of charcoal iron. It has only been moderately successful, however, in meeting the claims made for it. It would seem that it is impossible for this alloy to equal the product which I shall presently describe, since this product is far superior in quality to charcoal iron.

NICKEL

Nickel seems to be one of the few metallic elements which produces a truly beneficial effect on the character of cast iron. Its highly beneficial effect on steel has long been understood, but this effect does not begin until the amount of nickel exceeds 3.0 per cent. Beneficial results are derived by its presence in cast iron to the extent of only 1.0 or 2.0 per cent. It strengthens the iron and improves its chilling power, without appearing to cause any lamination or other objectionable features. These statements are based solely upon some experience made at Ashland by remelting irons in the crucible with nickel sufficient to give the above-mentioned percentages, and it would be unwise to generalize too widely on such limited data.

It is, of course, not to be overlooked that the expense of nickel for treating cast iron is almost prohibitive. One per cent, or 22 lb., would increase the cost about \$7 per ton, and that consideration, taken in conjunction with the fact that even nickel is not able to produce results as good as those obtainable with the new kind of iron presently to be described, makes this an unprofitable field for further research.

For strong, tough irons with hard, wear-resisting chill, no material has apparently been developed as good as an iron containing as much oxygen as its silicon content will permit.

TITANIUM

The effect of titanium on cast iron is a much-discussed question, and not nearly so much experience is available

¹Journal of the Iron and Steel Institute, 1892, vol. ii.

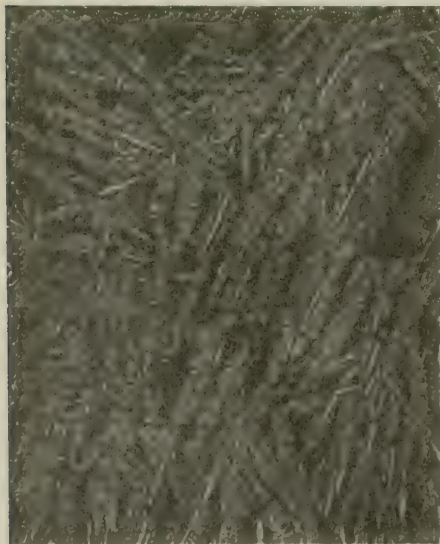


FIG. 35—ETCHED (MAGNIFIED 100 DIAMETERS) CHROMIFEROUS PIG IRON. NOTE SIMILARITY TO EUTECTIC STRUCTURE OF (MESH) SPOTTED IRON, FIGS. 3 AND 4 (PAGE 534)



FIG. 36—ETCHED (MAGNIFIED 100 DIAMETERS) PIG IRON WITH 4 PER CENT CHROMIUM. NOTE FLAT CRYSTALS AND COMPARE WITH FIGS. 3 AND 4 "SPOTTED" POOR CHARCOAL IRON

for the solution of it as in the case of manganese, but the probabilities are that the action of this alloy has also very contradictory effects, on account of its action on different elements.

An extensive paper on the subject was published by Prof. Bradley Stoughton before the American Institute of Mining Engineers in 1912, but the results recorded as to the effect of strength of cast iron, etc., were rather contradictory. One thing, however, seemed to stand out very clearly, and this was that titanium reduced the chill. This is in accordance with what we should expect, for titanium is one of the strongest deoxidizers known. It also has a very high affinity for sulphur and nitrogen. Such effect as nitrogen has is undoubtedly in the direction of producing chill, and therefore, the effect of titanium would tend to remove three elements producing chill, namely, oxygen, sulphur, and nitrogen. This amply explains why the chill is reduced, and probably explains also why the results on strength are so contradictory. The titanium removes the highly beneficial oxygen, and it also helps to remove the detrimental sulphur.

The reduction of chilling power which is admitted by advocates of the use of this alloy for cast iron requires the use of more manganese for its restoration, and this is highly objectionable, for reasons already pointed out, and it seems extremely doubtful that any benefit will be found by prolonged experience to result from the use of titanium in cast iron, even in spite of the fact that its action on the matrix of the iron itself may be to strengthen it. Its influence in removing oxygen in good castings is extremely detrimental, and this is probably not offset by any other beneficial action which it may have, while where particularly good castings are not required there is no call for the use of any treating material whatever.

VANADIUM

Following the general custom of claiming a beneficial action on cast iron for any alloying material which has been found useful in steel manufacture, traces of vanadium have been claimed to have a beneficial effect on cast iron. Vanadium, like titanium, is a powerful scavenger. Its best-informed advocates claim that its principal service is not in remaining in the steel itself, but in going out of it with the oxygen, nitrogen, etc., which it removes.

This is exactly the same effect as that produced by titanium, and it seems almost certain that vanadium will be found objectionable in good irons containing oxygen, as it has already been found to be without benefit for ordinary castings not containing that element.

Great claims have recently been made for irons containing traces of this element, but the photomicrographs used to illustrate the claims did not display a particularly meritorious structure, and the results of the physical tests given were so far below the results obtainable with irons containing oxygen as to be beneath comparison with them.

As a result of this review of all the metals that are claimed to benefit cast iron, we see that most of them, with the possible exception of manganese, have based their principal claims on being deoxidizers, although some also have merit as desulphurizers, and some have a direct effect in throwing the carbon into the combined condition.

We have already seen, and I trust that I shall be able to show still more clearly presently, that oxygen is of greater benefit to cast iron than any other element at our disposal, with the exception of silicon, and that any addition to the iron which tends to remove oxygen is not beneficial to it, but is highly objectionable, the accepted theories to the contrary notwithstanding.

We have seen, by unmistakable evidence also, that, while some of these metals tend to throw the carbon into the combined condition, the form into which they throw it (or rather the type of crystallization which they induce) is an extremely objectionable one, being inherently weak and brittle, and that the sole benefit which we can expect from the use of these metals is the removal of a portion of the sulphur, for which a small amount of manganese seems to suffice—at least to the extent to which such removal is possible. When this result is accomplished with manganese in moderation, the strength of the iron is not materially impaired, though its chilling power, in the judgment of some expert users, is decreased after the manganese increases above 0.3 per cent.

It seems safe to say, therefore, that, if it were not for sulphur, the more perfectly we dispensed with any of these alloying metals the better iron we should obtain where strength, close grain, and strong, hard chill are the qualities desired.

Remember now the demonstrated fact that the old-fashioned cold and warm blast charcoal iron contained much oxygen, and you will understand that the conscientious founder, in his insistence on the use of these materials for high-grade chilled castings, was not actuated by prejudice and ignorance, but by a profound knowledge of his subject, even though he could not explain the reason for the results produced.

It will be clearly recognized that this is a flat contradiction of the tenets of theoretical metallurgy, but we find it necessary in every science to recognize, from time to time, the fact that we have taken a wrong trail and are being led from, not toward, our goal, and the only thing to do under such circumstances is to leave that path and take up the correct course, even though we have to retrace our footsteps in doing so.

A critical examination of the basis of the old theory will disclose the fact that the amount of real evidence on which it rested was small. No work of any amount in determining the actual oxygen present in cast iron by the combustion method has ever come to my attention, except that which we initiated at Ashland, and, while some work has been done by solution of the iron and determining the residual oxide, this method cannot receive much consideration on account of the vast possibilities of oxidation during solution.

It is true that there is a vast amount of inferential evidence available to the careful observer that oxygen produces a difference. I was convinced that there was oxygen in some iron ten years before I had obtained any determinations of that element, and the results of the subsequent determinations have shown that I was right, but, because the iron produced was for steel-making purposes, and, when high in oxygen, was generally high in sulphur also (and therefore rejected by the steel works), I considered the effect of oxygen harmful. This was a coke iron, and when I first saw the "special" charcoal iron I condemned it as worthless, because of its strong resemblance to this high oxygen coke iron. The introduction of the testing machine soon showed the complete fallacy of this judgment.

On the other hand, much has been said as to the burning of iron by overheating it, and its poorer quality when overheated has been attributed to the introduction of oxygen, especially in air-furnace work. The explanation will work just as well if turned the other way around. When metal is overheated in the air furnace the oxygen, of which that apparatus introduces a little, reacts with the silicon or carbon, or both, and goes out, weakening the iron and impairing its quality, just as the exponents of the "burning" theory contend.

The fact that increasing temperature promotes the

elimination of oxygen is proved by several facts. The "Experiments on the Overoxidation of Steel" carried on by Messrs. Shimer and Keachline, and reported by them in a paper before the American Institute of Mining Engineers, showed that, as the temperature went up, less oxygen stayed in. These investigators found less oxygen in steel with only about 1.0 per cent carbon and no silicon than we find in cast iron with 3.5 per cent carbon and 1 or 2 per cent silicon, because the temperature of molten steel is some 500 deg. higher than that of cast iron.

In the course of my own experience, I have seen a heat in a small converter purposely blown cold until the silicon was removed, but most of the carbon left in. This metal was alive with oxygen. It was exceedingly "wild" when hot, and when cold it was so full of blowholes as to have no strength whatever. The same iron, blown hot, yielded steel of a very high temperature, containing only about 0.06 per cent carbon, and was absolutely quiet, even before the addition of the deoxidizers, and poured like cream.

All these facts agree with the well-established general law that the affinity of carbon for oxygen increases very rapidly with the temperature. You will see then that, while the view I am offering you is opposed by an accepted theory, it is supported by a vast array of established facts.

In spite of the volume of evidence which we have accumulated, and which I have set forth in the published paper above mentioned, I am well aware that it would be impossible for many to accept my conclusions on this evidence alone. I shall pass, therefore, to the second stage of my subject, namely:

The Production of an Iron High in Oxygen and the Characteristics of Such an Iron

When I had obtained what seemed reasonably valid testimony that oxygen was the cause of the good qualities in charcoal iron, I began to experiment with methods of introducing it at will by different ways of operating the furnace, and also by introducing hot ore, mill scale, etc., into ladles and then filling the ladles with iron as it came from the furnace. This yielded no useful result.

After I had left the charcoal iron business I began to investigate further the conditions under which silicon and carbon were removed from iron during its conversion into steel, in order to obtain a method of introducing oxygen into iron at will without lowering the carbon. I found from the steel men that by starting with a very hot heat in the Bessemer, they could blow the carbon out to a very considerable extent before the silicon was gone, while with a comparatively cold initial heat the silicon would practically all disappear before the carbon began to be removed. Moreover, it seemed perfectly evident that the reason I had been unable to get oxygen into normal irons, either in or outside the furnace, was because, at the temperature at which I was working, the activity of the silicon and that of the carbon were such that they instantly removed the oxygen.

It is, of course, no trouble to resilicowize a bath of metal, and therefore it seemed to me that if I could take metal and reduce it to the condition of the spongy white iron, which we obtained from the furnace when it was so cold as to be almost chilled, and could then mix that with normal iron high enough in silicon to give the resulting mixture the desired silicon contents (all the while keeping the temperature as low as possible), I should reproduce, outside the furnace, the conditions which had existed inside it, always providing that the temperature was kept low enough, because ob-

servation of converter practice had convinced me that 0.05 per cent carbon was more efficacious in removing oxygen at 3000 deg. than was 3 per cent at 2300 deg.

Accordingly, therefore, I had preliminary tests made at a steel-casting plant. A heat of metal of 1.0 per cent silicon was blown in the side blow converter, holding the temperature down by stopping the blow and turning down the heat several times. The blow was continued until the carbon flame began to break through, showing that the silicon was gone and the carbon was beginning to go. The blow was then stopped and the vessel turned down. The sample of metal taken from it at that time was, when cold, a white iron full of blowholes, rotten, brittle, and worthless to the last degree. With this was then mixed an equal volume of 2.0 per cent silicon iron direct from the cupola, and from that mixture test bars were cast. Test bars had also been cast of the original metal, both the 1.0 per cent silicon iron and the 2.0 per cent, and these broke at approximately 2300 lb. on 1½-in. round bars on 12-in. centers. Similar bars from the treated metal broke from 4000 to 4300 lb.

Steps were then taken to obtain patents on this process, and in view of the current opinions in metallurgy, there were but few citations from the Patent Office of anything of a similar nature. On the contrary, the patent examiners found my statements and claims so utterly at variance with all the accepted theories on the subject that they were inclined to consider me a victim of self-delusion. However, we had at hand a mass of evidence, and when it was presented to them they became convinced that, while there was a conflict between the accepted theories of metallurgy and the facts, it would be better to give precedence to the facts, and let the accepted theories go, and they allowed the patents in their broadest possible form.

After this a number of furnace companies were approached, with the view of having them undertake the manufacture of the new metal, and, unless one had experienced it, one would not believe with how little enthusiasm the proposal was received. Finally I went to Mr. E. A. S. Clarke, president of the Lackawanna Steel Company, and he asked me to go to Buffalo to see those in charge of the company's plant there, at the same time accompanying his invitation with intimations of the skepticism of all parties in regard to my process and the results claimed for it. When I reached Buffalo this skepticism was made even more evident and put in more direct language, but when I showed them the experimental results which I had obtained at the steel-casting plant they waived their doubts for the time being, and consented to make a trial of the process.

At the first attempt, the conditions were not altogether favorable. A plant laid out for the production of steel, with no idea of ever desiring to oxygenate pig iron, may obviously not be ideally arranged for the latter purpose, while blowers, familiar with the necessity of getting a high temperature to produce good steel, found it difficult to blow a heat as cold as possible. Moreover, the iron which was used to mix with the blown metal was lower in silicon than we had expected to get, and this resulted practically in a "mottled" iron. All these conditions militated against the success of the trial.

Nevertheless, test bars, made from the metal after treatment, showed an increase of about 20 per cent in strength over the original iron even after remelting, and the Lackawanna Company then felt justified in making another test and arranging the conditions more in accordance with the requirements of the operation. At this second test we provided a metal of about 2.5 per cent silicon to mix with the blown metal. The phos-

phorus was also increased so as to give a result comparable to foundry iron. The metal to be blown was taken from the mixer, and was mixed half-and-half with the high silicon metal, and test bars $1\frac{1}{4}$ in. round and 2 in. square were cast from the mixture to determine the strength of the iron before treatment. After the converterful of mixer metal was blown the high silicon iron was added, and additional test bars were made from this mixture. The $1\frac{1}{4}$ -in. round test bars of the original untreated metal broke at about 3100 lb. average; high silicon metal, and test bars $1\frac{1}{4}$ in. round and 2 in. centers.

Of the treated metal, the $1\frac{1}{4}$ -in. test bars broke at about 5100 lb. average, and the 2-in. square test bars broke at 22,900 lb. average. The $1\frac{1}{4}$ -in. test bars were a little over size in each case, but about the same amount in each, so that the results are comparable. By a curious coincidence, the increase in strength, based on the average of all the good bars, worked out to exactly 70 per cent in both cases. Since that time other heats of other silicon have been made, and the strength is in all cases well above 20,000 lb. on the 2-in. square bar.

The first questions you will naturally ask are: Does the oxygen stay in this iron on remelting, and, if so, why? Why do not the carbon and silicon which are present scour it out, and restore the iron to its normal condition?

The answer to the first is the important one from the commercial point of view, and so soon as we have obtained these results we put some of the iron produced through a cupola as a separate charge. When it came out we raised the silicon with ferro-silicon from 1.26 to about 1.50 per cent so as to make it comparable with ordinary iron from the cupola. Even after this treatment with ferro-silicon, which tended to deoxidize it and also to throw out the carbon into the graphitic condition, the strength remained at 21,000 lb. We had previously demonstrated, by an extensive series of remelts of charcoal iron in crucibles, as described in the paper above mentioned, that the oxygen did remain, and that, as I have already stated, an iron which went into the crucible strong came out of it strong. The actual presence of the oxygen after remelting, as well as before, was determined by analysis before and after the results.

The reply to the second question seems at first sight more difficult, but it is not really so. It seems to be a perfectly general law of chemical action that, while reactions go on in concentrated solutions along certain lines and proceed at least nearly to completion in such solutions, in dilute solutions the same law does not hold. Take, for instance, the case of manganese and sulphur. You know very well that iron sulphide is broken up by manganese; the sulphur is seized and forms manganese sulphide, leaving the iron, and the manganese sulphide then leaves them both. Now, if this reaction proceeded to completion, it should be easy, by adding an excess of manganese, to take out *all* the sulphur. But, as a matter of fact, you are perfectly well aware that this is entirely impossible; that each unit of sulphur is harder to remove than the last; and that you reach a point beyond which the addition of further manganese does not reduce the sulphur at all. I take the same to be the case in regard to oxygen, only that the equilibrium point is lower and the influence of temperature is more important, so that, if the temperature be kept moderate, the oxygen will remain to some extent, unless powerful deoxidizers are added.

In this connection I may say that we had an accidental confirmation of the correctness of the oxygen theory, which may not be without interest. By accident, one heat of the new metal was made with iron

about 3.0 per cent in manganese, so that the resulting mixture contained $1\frac{1}{2}$ per cent. The strength of this iron was reduced 3000 lb.—*i.e.*, from about 21,000 lb. to about 18,000 lb.—on the 2-in. square bar as compared with iron identically the same in all particulars, except that the manganese was normal, or about 0.4 per cent.

There are two other questions of interest:

First.—In what respect and for what reason is this new material better than the so-called semi-steel (cast iron with a mixture of steel scrap)?

Second.—How do we achieve the advantage of high carbon, which, it is my belief, is one of the advantages of cold-blast charcoal iron for special purposes?

The answer to the first may be divided into four portions:

(a) The effect of oxygen is to reduce the graphite to a fraction of its injurious area, by changing its shape. This is obviously far superior to a simple dilution of the carbon, which can only reduce the graphite by about a third in the most extreme case.

(b) The temperature required for the melting of steel scrap is very high, materially above that of an iron with normal carbon. This requires such iron to be raised to a higher temperature than iron with normal carbon, and facilitates the elimination of any oxygen which it may contain.

(c) The use of steel scrap dilutes the carbon and reduces the quantity of cementite which can be formed, so that chilled castings made in this way have not the hardness and wearing qualities of those made of irons with high carbon when the latter is all combined.

(d) It seems certain that carbon in proper condition facilitates the machinability of an iron, remembering that this carbon is in the form of graphite, one of the best lubricants known. It has been demonstrated by experience that an iron of a given strength of matrix machines more easily if it contains more carbon, without necessarily being weaker than low carbon iron if the carbon be in more nodular form than that in the low carbon iron.

The answer to the second question is that, by the hot operation of coke furnaces with a limy slag, the carbon can be forced up to or beyond 4 per cent, and by proper operation in treating it we can preserve practically all this carbon, thereby securing an amount equal to that of the cold-blast iron. Whether we shall be able to go beyond this, and introduce additional carbon during or after the treatment, I am not able to say, because we have made no experiments along that line. It seems likely that this will be unnecessary in practice, for most of the users of cold-blast charcoal iron use it in the air furnaces, and reduce the carbon to between 3.5 and 3 per cent before casting, an amount which we can easily exceed.

We have had a number of tests made by parties who were interested in the purchase of iron. Some of these I am not at liberty to publish, but the representative of one large railroad company has told me privately that it found the strength and chilling power of the iron to be virtually the same as that of one of the famous brands of Eastern charcoal iron. Another railroad company reported that it found the breaking strength of the iron in 2-in. square test bars on 12-in. centers to be 25,000 and some odd pounds; while through the kindness of Mr. Harry B. Swan, of the Cadillac Motor Car Company, I am able to present a table of results of crucible remelts made from this iron.

CADILLAC RESULTS

Analysis	Combined carbon	0.85
	Graphitic carbon	2.65
	Manganese	0.26
	Phosphorus	0.326
	Sulphur	0.039
	Silicon	1.25

The test bars showed the following results from the Standard 1¼-in. round bar of the American Society for Testing Materials, on 12-in. centers (four bars gave the following results):

	A	B	C	D
Transverse strength in pounds.....	4,505	4,825	4,825	4,875
Modulus of rupture, pounds per square inch.....	67,300	67,100	67,100	66,400
Tensile strength, pounds per square inch.....	34,800	33,800	34,100	33,800
Brinell hardness.....	202	207	202	196

Charcoal iron showing above 3000 lb. on the 1¼-in. test bar is strong enough to be put into a class of special iron by itself, while one of 4000 lb. strength is very rare. You will see that this iron is about 60 per cent stronger than the former, and about 20 per cent stronger than the latter. The closeness of its grain you will see from the samples and from the photomicrographs (Figs. 28 to 31). These latter also show the graphite in this iron to be almost completely nodular, rather than of the flake variety, and show, in the most unmistakable manner, why the iron must be stronger than an iron the same matrix, but with wide flakes of graphite. The effects of oxygen in changing the form of crystallization and in preventing the breaking down of the combined carbon are the same in this iron as they are in charcoal iron, except that worm-blast charcoal iron contains only from 0.015 to 0.30 per cent oxygen, whereas we have no difficulty in obtaining 0.050 to 0.70 per cent oxygen, with correspondingly greater effect in these two directions.

The experiments which have been made on actual castings show also that the suppression of the eutectic is more than a scientific hypothesis. One large company found that a certain casting was extremely difficult to make of ordinary iron without having shrinkage cavities along a certain line, but that, when poured from this iron, the castings were absolutely sound at this point. This I believe to be because the iron solidifies all at once as a homogeneous mass instead of passing through a long range of progressive freezing. The last freezing or eutectic portion is that which is altered by the presence of this minute quantity of oxygen into something else with a higher melting-point.

Returning now to the iron-carbon diagram, a valuable suggestion has been made by Professor Campbell, to the effect that there are shown by Fig. 2 several paths along which iron-carbon alloys may pass in cooling; that one of these may result in one structure and another in another, and that the presence of a small quantity of oxygen may be the controlling factor which forces the cooling to take place according to one of these paths or another. This suggestion, combined with the diagrams of Guertler and Upton, goes further to account for the facts as we found them in practice than any other that has been made. The suggestion from Upton, that graphitization occurs on one side of the eutectic point below the eutectic freezing temperature and not on the other, is very much in line with the observations of practice, for it is a fact that certain irons will throw off graphite into the air in great profusion while running from the furnace, whereas other irons of similar composition and perhaps even higher in carbon will show no such tendency whatever. This is particularly true in relatively low carbon coke irons of about 1.0 per cent silicon and relatively high carbon charcoal irons of about the same silicon. The latter scarcely ever makes any show of graphite as it runs from the furnace. The other fills the cast-house until it looks as though a black snow-storm were in progress.

The practical questions may now be asked: Granted that we have here a new material, what is it good for?

The answer is that it is good where strength, closeness of grain, steam tightness, and wearing qualities

are desired. Above all, it is good where chilling power under strict control and hard, strong chill are desirable. Because irons containing oxygen have this peculiarity, they not only begin to show a chill at a higher silicon percentage than do coke irons, but they are also much more sensitive to chilling influences. High oxygen iron of 1.25 per cent silicon will show no more white chill than a coke iron if cast in sand, though, of course, it will be much finer grained. But, if cast against a chilling surface, it will show from ⅛ to ¼ in. white chill, whereas when coke iron reaches the range of silicon within which it will "take a chill" it is with difficulty prevented from chilling, even when cast in sand. With this great strength, with this power of making intricate castings without shrinkage cavities, and with its chilling power under accurate control, it seems that the metal should find its largest field, measured in tons, in car wheels, and tests of it for this purpose are now under way. Outside of that field, the metal is particularly adapted for steam, gas, or ammonia cylinders. As a substitute for or improvement on "gun iron" for strong castings, such as are now made from the air furnace, I believe that this metal cast from the cupola will find a large field of usefulness.

It is our hope, also, that with this metal it will be possible to produce malleable castings by melting in the cupola as easily as to produce them from the air furnace, as is done in present practice, because we can supply the carbon of any amount desired, and we can also introduce the oxygen, which it is largely the function of the air furnace to put into the iron now. This statement may seem radical, but I have had made an analysis of malleable iron, and found it to contain 0.13 per cent oxygen. Moreover, malleable iron, which under the microscope is shown to be composed of iron interspersed with little round nodules of graphite or temper carbon, is only a step beyond the metal which I have shown you, and, in my judgment, the new metal will eventually be found to constitute an intermediate step between malleable iron and ordinary cast iron. In malleable iron the carbon is all retained in the combined condition, as in cast, and is subsequently graphitized against the resistance of the solid iron by prolonged annealing. The new metal delays graphitization until the structure is sufficiently solidified to resist the formation of the graphite, the resistance being sufficient to force the latter into the forms entirely similar to those in true malleable.

Where castings are made from the maximum percentage of cheap scrap with the minimum of new iron to carry this, a softener is needed, probably in part because of the high sulphur of the mixed scrap; and as this new product tends to produce high combined carbon, and is a strengthener (and to that extent a hardener), it is not recommended for such castings. On the other hand, where a high silicon strong iron is needed, so that it may have good machinability and lend itself to rapid manufacture and yet be strong and fine grained when finished, the ideal material to give these qualities can be made by the new process, and, once the exact combination of strength and machinability desired by the foundrymen is known, that combination can be repeated under conditions of strict control to a extent not possible with any other product.

Iron from the blast furnace has to be taken as produced, not only in oxygen but in the other elements, but, by the use of a mixture of known components, in combination with this process of treatment, we are able to produce iron not only of a given analysis, but with certain physical qualities accompanying that analysis, a degree of control impossible to obtain in iron direct from the blast furnace.

(To be concluded)

Design of Acid-Resisting Iron Apparatus*

By Norman Swindin

The introduction into the chemical industry some few years ago of iron alloys capable of resisting the action of ordinary commercial acids was an event of great importance. To substitute for ordinary earthenware apparatus, whose uncertain behavior to the chemical engineer is only too well known, properly designed plant made of metal was held to be too good a thing ever to be realized. It was seen at once that the development of these alloys would confer upon the chemical engineer the same advantages in the choice of plant for dealing with acids as are possessed by his kinsman, the gas engineer, in dealing with his tars, liquors, and gases.

The marketing of plant and apparatus constructed of such alloys was welcomed with eagerness, and the pioneers of their manufacture were deluged with orders many times the capacity of their foundry. Inquiries for every conceivable vessel and appliance associated with the manufacture and treatment of acids came pouring into the office. From railway tank wagons to trembler contacts the firm was asked to quote for.

Since then the chemical industry in its demands has become more reasonable, for many of the early failures in the use of the metal were due to errors in design, and especially to the duplication in the new metal of plant designed to suit the properties and characteristics of glass and earthenware. No doubt certain extravagant claims put forth by the pioneers concerning the properties of their new alloy led the industry to expect little short of miracles, but the appearance in the market at the present moment of several forms of these alloys shows evidence of a sounder appreciation and understanding of their properties.

Most of these metals are alloys of iron and silicon in varying proportions, together with small quantities of other elements. Their acid-resisting properties are acquired at the expense of other desired properties which, to mention two of the most important, are toughness and softness. In other words, the more resistant the alloy is the more brittle and hard it becomes. In time, with development, these defects will disappear, but for the present the chemical engineer has to substitute for his present earthenware plant iron apparatus which will perform the same functions.

Though it is claimed that the resistance to corrosion offered by certain of the new alloys is general and not specific, it is found in practice that of all the ordinary commercial acids, nitric has the least action on them. Accordingly, therefore, the nitric acid industry is the one most concerned with the development of the alloys as they are at present manufactured.

In the first place, consider these alloys to be brittle and hard—in short, as a kind of earthenware metal. In reality they are, when properly made, by no means so brittle, but an exaggerated idea of this property will do no harm.

Though it is possible to obtain parts with flanges and faces nicely ground, or even machined, do not adopt them unnecessarily. Plain spigot and socket joints are to be preferred. Parts of plant intended for the transmission of heat may be made much smaller than the corresponding parts in earthenware. These alloys transmit about ten times the quantity of heat that can pass through an equal plate of earthenware or silica ware. Remember, it is not wise to order parts of plant weighing more than a few hundredweights, nor above 3 ft. or 4 ft. in diameter or in depth. Firms may, and

can, undertake the delivery of much larger pieces of plant, but their use is risky, and when they fail a larger quantity of material undergoing treatment is wasted.

The design generally of plant made of iron acid-resisting alloys follows that of steel practice, with the difference that these alloys are much weaker to resist fracture from the action of internal stresses. The crystals of these alloys are much larger than those of steel, and consequently do not knit together so well on cooling. The reduction of internal stress is the chief end which the designer keeps in view. Unequal cooling due to bad distribution of the masses of metal in the castings is the chief source of trouble in this respect. Consequently the thickness of the metal in the casting should be as uniform as possible.

The big masses of metal formed at the juncture of two or more walls must be avoided. Very often at these points segregation of carbon bodies takes place and cavities form in metal of peculiar sponginess.

As it is not possible to use chaplets (*i.e.*, small metal supports which the founder puts in the mould for holding up long cores), because they do not fuse properly in the castings; all cores must be as stiff as possible and well supported in the prints. This point affects design by demanding large openings to act as core prints, and to enable the core material and core irons to be easily withdrawn.

Sharp corners must be avoided, because it is well known that crystallization takes place in lines normal to the surface of the casting; hence at the corners lines of cleavage are formed which become sources of weakness.

It may be helpful to consider the design of the commonest elements of plant and apparatus in detail which the chemical engineer requires in iron alloys.

PIPES

Pipes are, in general, the most successful form in which these alloys can be cast. Pipes, as distinct from tower elements, should not exceed 2 ft. in diameter or be less than 1 in. in diameter. The length depends upon the diameter, but the shorter the better, as, on account of the difficulty of supporting a long core without chaplets, it gives the foundry a better chance of producing a sound casting. The following table may be of assistance in determining the length of pipes:

Diameter (inches).....	1	2	3	4	5	6	8	10	12	18	24
Length (feet).....	1	2	3	4	5	6	8	10	12	18	24
Thickness of Metal (inches) 7	16	12	8	6	5	4	3	2	1	1	1

Whenever possible prefer sockets to flanges. There are now to be had excellent cements for every kind of acid liquids and gases, and as these bodies are seldom subjected to high pressures, an ordinary cemented joint can be made quite tight.

Pipes conveying liquids and gases under pressure must perforce be flanged, but the chief objection to them is that should the joint leak the corrosive body attacks the wrought-iron bolts. Flanges should be provided with a deep facing strip and be truly machined or ground.

At first the bolts were fitted in cast in slots of ample clearance, but cast holes, round or square, should be specified because the nuts, washers, and bolt heads have an increasing bearing surface, thus reducing the intensity of pressure on screwing up. Fracture of the corners of the slots is a frequent source of trouble.

The ordinary British standard pipe flanges for heavy steam pipes may be safely adopted as regards diameter, number, and position of bolts, and diameter of bolt circle. The thickness of flange should be about one and a half times the thickness of pipe walls.

There is doubtful wisdom in the use of webs. They

*From the "Chemical Trade Journal and Chemical Engineer" (London), Oct. 14, 1916.

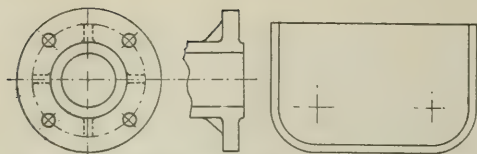


FIG. 1—PIPE FLANGE

FIG. 2—PAN CONSTRUCTION

facilitate the flow of metal into awkward corners of the casting, but as they are usually made large and fill the angle across which they sit, webs often crack, and thus serve no purpose. When adopted, webs should be small, not filling the angle, and slightly thinner than the walls of the casting.

Fig. 1 shows a typical form of pipe flange.

PANS, VESSELS, AND STILLS

The most successful form of casting for acid-resisting iron alloys, or indeed for any metal, is a hollow sphere. The nearer the castings approach this form the more reliable they are in use. As the lines of crystallization are in all parts normal to the surface and parallel to each other, the internal stresses are in consequence reduced to a minimum.

The design of pans and vessels, therefore, should evolve from the sphere. Flat surfaces should be avoided wherever possible; if they cannot be, then on no account must a flat surface exceed 18 in. square.

The intersection of two flat surfaces must be carried out by large radii, as in Fig. 2; in other words, there must be no sharp corners.

Circular pans with elliptical or hemispherical bottoms are excellent shapes. The only objection to them is that they do not sit well unless provided with feet or lugs, which, being projections, are liable to fracture if knocked or jarred unduly.

Two spherical ended pans, when bolted together flange to flange, form a very convenient acid tank or receiver. These have been made 5 ft. by 10 ft. long, but it is not recommended to specify them so made, to be more than 3 ft. 6 in. diameter by 10 ft. long—that is to say, made up of two pans, 3 ft. 6 in. diameter by 5 ft. deep.

For such vessels as receivers, bleachers, Woulfe's bottles, which are usually required with flat bottoms, the difficulty of casting these flat bottoms is overcome by dishing upwards as shown in Fig. 3. The form shown in Fig. 4 is, however, to be preferred.

The outlet or run-off pipe of stills should be as large as possible, and conical in section. In other words, the pipe should be attached to the still by large radii, as in Fig. 5.

Still covers and lids do not present great difficulties provided they are well dished. The best section for these is a semi-ellipse with flanges.

The very shallow pans used for concentration purposes are ribbed and corrugated to break up the flat surfaces. These ribs and corrugations, in addition to overcoming foundry troubles, provide an increased heat



FIGS. 3 AND 4—BOTTOM CONSTRUCTION

transmission surface. Pans of this pattern have been cast 3 ft. long by 18 in. wide and 6 in. deep. The design of lip needs care. The lip should be well curved and carried below the overflow level.

NITRIC-ACID PLANT

As before stated, it is in the nitric-acid industry that the greatest development of the use of these alloys is taking place. Their introduction into the atmospheric nitrogen industry has rendered possible the production of strong nitric acid by concentration from 22½ per cent acid.

Studying the ordinary nitric-acid plant, where sodium nitrate is treated with strong sulphuric acid, the greatest defect is the condenser. This may consist of a yard full of earthenware Woulfe's bottles connected in series, coils of Doulton or other ware, and of silica, vertical standpipes connected with glass tubes (Hart condenser), special forms of thin earthenware pipes (Guttman). The size of these condensers is enormous compared with the small quantity of heat that has to be

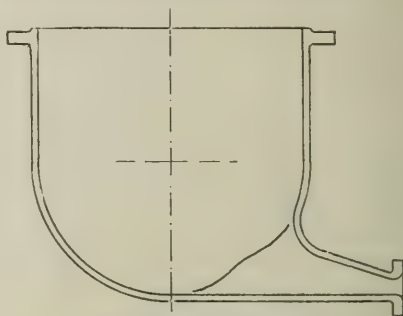


FIG. 5—STILL AND PIPE

absorbed to condense the nitric-acid vapors, because the heat conductivity of the material is so bad.

Iron alloy condensers in the first place are much smaller, and as the condensation can be performed rapidly, the reaction in the still can be forced so that a charge that usually take thirty-six hours may be reduced to sixteen hours.

The usual form of metal condenser consists of a series of pipes fixed in frame for air cooling, or better placed in a water tank with the joints outside. The joints are usually flanged, but it is much to be preferred to have sockets, which should be fixed in a vertical plane.

The now familiar form of "S" pipe suggests itself as the best means of having vertical socket joints with horizontal pipe (see Fig. 6). If these pipes are gilled as in Fig. 7, and fitted so that they can be covered with films of water, no better form of condenser need be desired.

The newly developed industry of atmospheric nitric acid has brought forth many difficult problems. To remove the water from 22½ per cent nitric and produce 100 per cent acid, it has been found necessary to evaporate, fractionate, and distill in succession. Plants have already been designed to carry out the first two operations in vacuo and constructed entirely of acid-resisting iron alloy.

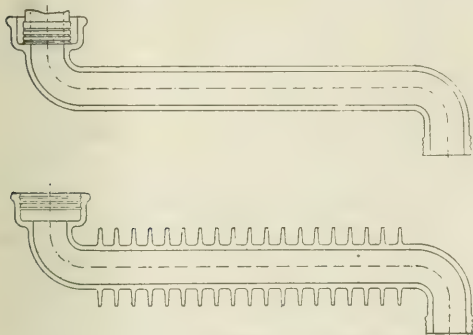
Apart from the difficulty of grinding or machining a great number of joints with the necessary accuracy—for it must be understood that this plant is a great departure from the simple still set in brickwork with condenser pipes that need not be machined at all—the designing of a steam-heated still presented a stiff problem.

The heating elements of the still were, after many disappointments, made by casting in a strong steel coil in the walls of the element. These elements were like inverted saucers, and a number of them resting together were bolted between a pan-like base and a still cover. It is not intended here to describe in detail how this was done; it is sufficient in an article of this nature to mention the fact that steam-heated stills so constructed can be obtained.

The condenser of this plant deserves mention. It was constructed on the lines of an evaporative condenser of a condensing engine, and was placed outside the building and supplied with water in the usual way. The function of the condenser was different from that attached to a nitric-acid plant. It had to condense $2\frac{1}{2}$ tons of water-vapor for each ton of acid produced.

SULPHURIC-ACID CONCENTRATION

The early forms of apparatus for carrying out this terrible business were not altogether successful. Though thousands of cascade pans and basins have been supplied and put to use, the silica basin, notwithstanding its low heat conductivity and its liability to flake, is



FIGS. 6 AND 7—CONDENSER CONSTRUCTION

still largely used. Where iron-free acid is required, silica is imperative, for none of the iron alloys can resist absolutely the action of weak sulphuric acid.

It was early found that when cascade plants were wholly fitted with iron alloy pans the iron sulphate formed in the top basins where the acid was weak was deposited in an anhydrous condition in the lower pans, and eventually stopped the flow of acid, or, rather, directed it down into the furnace, where it made the usual mess. It is usual at the present time to fit cascade basins of iron alloy only in the lower part of the run, for strong acid does not attack them, and they, of course, transmit the heat much easier.

For denitrating mixed acid, towers made of iron alloys are very successful. They are made up of socket pipe lengths and placed on a bottom element having an outlet for acid and an inlet for steam. An ordinary form of still elbow with seal on the top completes the tower.

Bitumens.—Arranged in convenient question and answer form with space for additional memoranda, The Barber Asphalt Paving Company has published an "Outline for the Study of Bitumens." While the whole subject of bitumens is covered, the outline has been prepared with especial reference to the asphaltic materials used in highway construction. In addition to the answers provided in the outline itself, there are references to most of the standard text books on highway engineering. While prepared especially for school use, the outline is a convenient means of reference for anyone interested in bitumens.

Inadequacy and Inconsistency of Some Common Chemical Terms

By Carl Hering

The fact that our grandfathers did things in a certain way, and that this way was good enough for them, is not always a safe reason for our doing so to-day, although when stated in different terms this reason is often accepted to-day by some as safe and sufficient. Physical chemistry has done so much lately for the advancement of chemistry that its dictates should receive respectful consideration.

The purpose of the present article is to point out the looseness, inconsistency and inadequacy of some common conceptions, terms, and expressions, in chemistry, and to suggest reforms.

Valence. The term valence, meaning the number of bonds which unite the elements, or the number of atoms of different elements which combine into a molecule, has been used rather loosely, causing confusion and inconsistencies. It would avoid confusion and be more clear and precise, if the term "valency" were used to express the general *property* of an atom of that element to combine with other atoms in various proportions, while the term "valence" should then be limited to the *one particular value* in any one specific case. Thus it should be said that copper as an element possesses the property of having a *valency* of 1 and 2, and that in cuprous chloride it has a *valence* of 1 and in cupric chloride a *valence* of 2. This reform has already been suggested by others and should be encouraged.

Different kinds of bonds. In what are known as structural formulas, some of the bonds are sometimes supposed to combine atoms of the *same* element. Thus in H_2O , one of the two bonds of O is supposed to unite the two atoms of O with each other. The modern and probably generally accepted theory of chemical reactions, at least in cases of electrolysis, shows that every one of the bonds between different elements (for a mono-valent gram atom) which is destroyed or created by the current involves an electric charge of one faraday (96,500 coulombs or 26.80 ampere-hours); this is true for all the elements, at least in electrolysis; the ions carry these charges from one electrode to the other; this is the basis of the generally accepted Faraday's law. To separate from each other two or more atoms of the *same* element by electrolysis, which would imply setting free the same element at both electrodes, is apparently not possible, and if this is true it must follow that those bonds which are supposed to unite atoms of the same element, if they exist, must be physically of a different nature, and should therefore be distinguished in some way or by some term from the other kind which are well known to exist and are universally recognized. In what follows the only kind of bonds referred to are those which unite different elements, and the term valence is here used as referring only to those.

Negative valences. Most of the elements will, in electrolysis, always go to one particular electrode and never to the other; hydrogen, for instance, always goes to the cathode and oxygen always to the anode. According to the modern accepted theories, hydrogen atoms always carry positive charges of electricity and the oxygen atoms always carry negative charges. This alone should be a sufficient reason to give the valences distinguishing signs, and therefore to say that the valence of hydrogen is +1 and that of oxygen — 2, hence to use negative valences, as was suggested many years ago (see the writer's article in this journal, January, 1903, p. 169).

But there is another and even more important reason for doing so. Some of the elements, namely, antimony,

arsenic, bromine, carbon, chlorine, iodine, nitrogen, phosphorus, selenium, silicon, sulfur and tellurium, seem to act sometimes like hydrogen in this respect, and at other times like oxygen; or according to modern theories they sometimes carry negative and sometimes positive charges, hence it is inconsistent not to distinguish between these different states as is easily done by giving the particular valence a sign; that is, by stating whether in any particular combination the valence is positive or negative.

As an illustration of the utility of this conception of negative valences, the S in H_2S must be considered to have a valence of -2 , while in SO_2 it must be considered as having a valence of $+6$. Hence to change the former into the latter involves a change of valence of -8 (the algebraic difference) and electrochemically this means 8 faradays and not 4, which would be the numerical difference if the negative sign be omitted; the sign of the difference 8 designates the direction of the current which would produce this result. Another illustration is the "oxidation" of methane CH_4 (more consistently written H_4C) into carbon tetrachloride CCl_4 . In the former the carbon should be stated as having a valence of -4 and in the latter $+4$, hence the change of valence involved is -8 and not zero, as would follow if the signs are omitted.

Change of valence. All electrolytic reactions must be considered broadly as involving a change of valence, no other kind seems to be known, and the quantitative calculations are based on this change. The oxidation of ferrous into ferric sulfate, for instance, involves a change of valence of 1 in the iron. The setting free of oxygen from water is depriving it of all of its 2 bonds, hence is a change of valence of 2. Some quantitative electrochemical calculations are greatly simplified by basing them on this change of valence, as every unit valence of such change requires 26.80 ampere-hours for each mono-valent gram atom of the elements.

Zero valence. By a zero valence chemists usually mean that the element never combines with others, which is the case for instance with the noble gases like argon, etc. This is not consistent because any element in its free and uncombined state necessarily has no bonds connecting it with other elements, hence when in that state it must be considered as having a zero valence. Reducing the metals or the gaseous elements to their free state by electrolysis, means changing their valence from what they had in the combination, to zero. And in those elements which have both $+$ and $-$ valences, the change from one to the other necessarily involves passing through zero, which is their free state. A consistent way of stating these facts would be to say that the *valency* (a property) of the noble gases is zero, and that the *valence* (a specific value) of all the elements, is zero in their free state. Or it may be said that elements like argon are non-valent.

Reduction. All chemical reductions, when interpreted according to modern accepted theories, mean a reduction of the valence, whether from $+$ to or toward 0 or from 0 to $-$ or from $+$ to $-$. Broadly therefore it is physically the same process to set free hydrogen from water, a reduction from $+1$ to 0, as it is to combine free oxygen with some element as far as the oxygen is concerned; that element is properly said to be oxidized, but the oxygen must be said to be reduced, as its valence (and therefore its oxidizing property) has thereby been reduced from 0 to -2 . Chemists will not like to apply the term reduction to this change in the oxygen, yet as it is physically exactly the same process and in the same direction as setting free combined hydrogen or a metal, it necessarily must be placed in the same class, and if it is not palatable to the chemist

to embrace this under "reduction," then a new term should be coined for covering this physical process more broadly.

Oxidation. Similarly with the chemical term oxidation, though in this case the term is even worse as it implies a combination with oxygen, yet it is to-day by general consent (though inconsistently) extended to include combinations with other elements also; $\text{Cu} + \text{Cl} = \text{CuCl}$ is called oxidation.

Setting aside the views of our grandfathers, what this word is really intended to mean in its broad sense is the physical opposite or reverse of reduction, hence the same process in kind but different only in direction; according to modern theories therefore it means broadly an increase in valence, from $-$ to or toward 0, or 0 to $+$, or $-$ to $+$, and of course this is independent of whether oxygen itself is involved or not. To combine a free element with oxygen, fluorine, etc., is to increase its valence from 0 to $+$, which process is to-day called oxidation of the element (not of the oxygen). But it is physically exactly the same process as to increase the valence from $-$ to 0, as for instance in setting free sulfur from H_2S , in which case the change of valence of S has been from -2 to 0. It is necessarily also exactly the same physical process as in setting free oxygen from an oxide, as the valence of the oxygen has thereby been increased from -2 to 0; to call this "oxidizing the oxygen" would probably not be palatable to the chemists, yet that is what it really is when considered broadly as a physical process; this inconsistency however is lessened by the fact that such oxidized oxygen (free oxygen) is a stronger oxidizing agent than combined oxygen, just as reduced hydrogen (that is, free) is a stronger reducing agent than combined hydrogen.

A term is therefore needed for expressing this physical process, namely the exact reversal of chemical reduction (a reduction in valence), and meaning broadly an increase of valence from $-$ to or toward $+$. Many years ago Prof. J. W. Richards suggested the term "perduction" (which the present writer used in this journal, January, 1903, pp. 172 and 174); the objection to it is that the chemists already use the prefix *per-* in the sense of *super-*, hence it gives rise to confusion. Numerous other terms have been suggested, like *preduction*, *induction*, etc., but the best one seems to be "adduction," suggested recently by Dr. Frederick H. Getman, as the prefix implies an addition, hence the sense of increasing or adding to the valence.

In the opinion of the writer the words "adduction" (for oxidation) and "reduction" are satisfactory terms to use, for these two identical though opposite or reversed physical processes, as it merely involves overcoming unreasonable prejudices against extending the old and well known term reduction to embrace broadly all cases of reduction of valences, and as this would not involve the inconsistency that was involved in applying the word "oxidation" to other elements than oxygen, there ought to be no difficulties in doing so.

Philadelphia, Pa.

Chain Drive for Aniline Kettles.—The Link-Belt Company with offices in the principal cities has issued a pamphlet illustrating the use of chain drive for operating reducers and other dye making apparatus. Chain drive is being used by the Schoellkopf Aniline & Chemical Works, Buffalo.

Removal of Iron from Water.—"The Removal of Iron from Municipal Water Supplies" is the title of a bulletin of the Division of State Chemical Research of Kansas. The author is James W. Schwab, and the bulletin appears as Vol. XVII, No. 8, of The Bulletin of the University of Kansas.

Synopsis of Recent Chemical and Metallurgical Literature

Brass

Annealing of Arsenical Brass.—In a paper presented at the recent meeting of the British Institute of Metals in London, Messrs. C. H. MATHEWSON and E. M. THALHEIMER of the Sheffield Scientific School, Yale University, gave the results of a study of arsenical brass for use in making heavy tubes. The tests were made on brass mixtures based on the use of Copper-Range Lake copper with 0.3 per cent arsenic, with the object in view of finding a mixture which would withstand hot-rolling into a circular disk $\frac{1}{2}$ in. thick, which is then annealed and cupped preparatory to being drawn into tubing. The alloy therefore, must also be very ductile when cold.

The results of the tests show comparisons between the properties of brass containing (1) 62.5 per cent copper and very little (0.024 per cent) arsenic, (2) 62.5 per cent copper and 0.120 per cent arsenic and (3) 61 per cent copper and 0.139 arsenic.

In the mechanical tests made after annealing and quenching at temperatures between 450 deg. C. and 750 deg. C., the arsenical brass was found to be superior in elongation and strength. The alloy with the smaller percentage of copper appeared less sensitive to variations in the rate of cooling. In general the authors concluded that the alloy made from the arsenical copper was superior for tubing to that made with electrolytic copper. To obtain the best results the rate of cooling should not exceed 5 deg. C., fall of temperature per minute to 550 deg. C., when the material may be quenched.

Reclamation of Brass Ashes.—A paper dealing with the recovery of the valuable metal and unburned fuel from brass ashes was presented at the Cleveland meeting of the American Institute of Metals by ARTHUR F. TAGGART. A sizing test on a typical casting shop ash showed 10.05 per cent copper, which for a 65-35 brass means about 4.5 per cent zinc. A sorting test on this material showed about 15 per cent unburned and partially burned coal. This is for normal operation, whereas at present these figures are much higher. The gross value of the normal ash is \$32.78 per ton, and under forced production \$100.90 per ton.

The method of recovering these values varies in different plants, according to the size of the plant and the consequent production of ashes, and according also to the technical talent available. A small number of small plants sell directly to local junk dealers, others ship to custom scrap metal plants; the large majority treat the ashes by some crude method to recover the coarse metal, some of these selling the fine residue at absurdly low prices, the others using it for filling in low ground around the plant. Finally there are a few of the larger companies that treat the ashes in modern, well-designed reclaiming plants, obtaining as products clean coarse metal which can be melted directly into ingots, and fine rich concentrate which is smelted on the ground and which also yields ingot metal.

The factors which must be considered in the design of such a modern plant are:

1. The character of the ashes.
2. The quantity of ashes.
3. The treatment of the products of the concentrating plant.
4. The characteristics of the machinery to be employed.
5. Costs, both capital and operating, and their effect on percentages of recovery.

The general system of handling these factors, once they are determined, is by the method of "cut-and-try."

The first step is to make a sizing-sorting-assay test of the original ashes. From this is gained necessary information concerning the distribution of metallic values and coal and the amount of slag that must be ground. Grinding, sorting and microscopic tests on the slag afford knowledge as to the distribution and size of the metallic shot which it contains and thus tell to what extent comminution must be carried in order to free for concentration the economic maximum of metal. From the knowledge thus gained an experimental flow-sheet or mill scheme is built up in the laboratory and a test run made to confirm the deductions from the original test. With the further knowledge gained from this test run, and, if necessary, subsequent test runs, a tentative flow-sheet for the mill installation is drawn up.

The costs of the plant will depend on the character of the housing. A small plant, with a capacity of 20 tons per day, housed in a wooden building, will cost \$15,000 to \$20,000, a larger plant, with a capacity up to 200 tons per day, housed in a steel building, will cost \$80,000 to \$100,000. A considerable reduction in these figures can be expected if a concentrating plant alone is built. If the plants of the writer's acquaintance are typical, either will pay for itself in increased saving and decreased cost of operation within a couple of years.

Seasoning Cracking and Self-Annealing of Brass.

—An interesting contribution on this subject was presented at the recent meeting of the American Institute of Metals in Cleveland by W. ARTHUR of the Frankford Arsenal, Philadelphia, Pa. The author states that it is only in recent years that much serious thought has been given to one of the less prominent but most important peculiarities of brass, viz., self-annealing and seasoning cracking.

Since it requires several years for any self-annealing or seasoning cracking to manifest itself to any marked degree, it is to be expected that any extended study would be much delayed. Often the brass which might show this property is entirely used up, worn out or discarded long before any marked change in the metal has occurred. However, there are instances where it may be necessary to store the brass or its use may extend over a period of a number of years. In such cases seasoning cracking or self-annealing is quite important. Thus it has been possible to make the necessary investigations only in cases where the metal could be kept under observation for a long period of time.

It is a familiar fact that hard-drawn brass wire when held in storage for any considerable length of time shows a decided tendency to lose its hardness or spring temper, and in a few cases where the temperature has been abnormally high these changes have come about in a comparatively short time. In many instances where brass wire has been employed because of its hardness or spring temper it became quite useless, though it had not been in actual service but held in storage. In some lines of work where brass springs are used the present tendency is to discard the brass and use steel springs which do not exhibit changes due to age.

Metallographic methods have not been in use long enough to enable us to ascertain the exact nature of this intercrystalline change, and so far as we know no direct proof is available that recrystallization actually takes place, but all evidence points in that direction. The question naturally arises why does not hard-drawn brass show cracks when annealed in the ordinary way? So far as we are able to observe, season cracks begin on the surface and extend inward. Any cracking due to a change in volume would be counteracted by the expansion due to heating.

The significance of this problem of season cracking and self-annealing is such that it should receive much serious attention from our best metallurgists. We cannot pass it by without considering it, and it is to be hoped that the near future will be productive of much data which will enable users of brass who have difficulties with this problem to more intelligently cope with it.

Valves

Failure of Manganese Valve Castings.—An investigation was made at the Bureau of Standards of the failure of a number of manganese valve castings in the Catskill Aqueduct. The results were described in a paper by PAUL D. MERICA and C. P. KARR presented at the annual meeting of the American Institute of Metals in Cleveland. A somewhat fuller account will later be published as a Technologic paper of the Bureau of Standards.

The castings were quite large weighing up to 22,000 lb., and were such that neither preheating of the casting for the welding or burning in of defective areas, nor subsequent annealing of the whole casting could be conveniently carried out.

As a result of the local heating of welding and consequent unequal contraction of different constrained parts of the casting, stresses remained in the casting, particularly severe near and within the burned-in areas; these stresses were in all probability responsible for the subsequent failure at these points.

The determination of the values of such stresses, in the case of castings of manganese bronze, in correlation with the physical properties and structure of this material as welded or burned-in seemed desirable.

The experiments described have indicated how readily severe stresses may be introduced into a casting by the burning-in or welding of a "constrained" area or portion of it. The form of casting used in these experiments was such that no bending or distortion, tending to relieve the stresses, was possible during cooling, and this must be borne in mind in applying these results to the consideration of the effect of burning-in of more complicated shapes, where such above-mentioned distortion does occur.

In the spherical shell or dome-shaped valve castings of the New York Board of Water Supply, for instance, burning-in would tend to flatten the shell, and in so doing, partially relieve these stresses, and it is most difficult to calculate the stresses in such a case. The authors are inclined to believe that even in these cases local stresses of values equal to the true elastic limit must have been produced, and which would account for subsequent failure.

The conclusions drawn, are:

(1) That the welding-in of constrained portions of castings (forgings, wrought articles, etc., naturally, as well) of manganese bronze, produces in general local initial tensional stresses within and near the burned-in zone, of value equal to the true elastic limit of the material, unless the shape of the casting is such that extensive distortion may occur.

(2) That such castings should, therefore, be either preheated carefully for welding, such that all parts of the casting cool down together from a dull red heat, or the casting should be subsequently annealed. Experience indicates that a low temperature anneal is sufficient for this purpose, e.g., from 400 deg. to 500 deg. C. (760 deg. to 945 deg. Fahr.) for from one to two hours. Either of these precautions should eliminate these local stresses resulting otherwise from the burning-in and should produce castings free from danger of subsequent cracking.

Molybdenum

Metallurgical Treatment of Molybdenum Ores.—In the Colorado School of Mines *Quarterly* for July, 1916. Prof. HERMAN FLECK in an article on molybdenum gives considerable data on the concentration and reduction of molybdenum ores. He reviews the various methods of concentration which have been tried.

"Nearly everything has been tried of ore-dressing nature on the molybdenum ores—no two of which are alike—and, on the whole, with surprisingly interesting results. Molybdenite is different from most minerals. It is heavy like a metallic sulphide and behaves in part like these, and then it is flexible, and not brittle, with strong basal cleavage and a tendency to flake like graphite or mica. Ordinary methods of concentration are hardly applicable.

"However, combinations of heat, newer principles, such as flotation, magnetic and electrostatic separation, have done much to win good concentrates from ores which were looked upon quite unfavorably a few years ago. Only rarely does the mineral occur so coarsely divided that it may be hand-picked."

Processes used in Australia, Norway, United States and Canada are reviewed. On the reduction of concentrates Professor Fleck writes as follows:

"Molybdenum is brought on the market in two forms, powder and ferroalloy.

"The first of these is invariably made by heating some form of oxide with a reducing agent. Carbon in form of charcoal is usually employed. The first stage of reduction is the dioxide which forms readily, and unlike the trioxide is not readily volatile. Prolonged heat and high temperature effect further reduction of this to metal.

"The second form, ferromolybdenum, with varying molybdenum contents, is made by the use of the electric resistance furnace, either direct from the sulphide or from the roasted high-grade sulphide. The advantage here is that impurities may be slagged off whereas in case of powdered metal, unless the impurities are subject to extraction with a solvent, they remain with the metal.

"Before the increased present demand manufacturers were exacting. Standard requirements for concentrates were 85 to 90 per cent MoS₃, and except in very small amounts, copper, bismuth, arsenic and tungsten, when present, were penalized. Because of increased demand the requirements are made more easy to meet.

"The reasons are obvious. The purer the molybdenite the less treatment required for the final operation of reduction. When the demand is greater than production, as at present, the increase in price takes good care of additional preliminary refining treatment of lower grade material. The preparation of the oxide in commercially pure form is not an easy matter.

"This may be done by roasting the sulphide first to oxide and then leaching the mass with ammonium hydroxide, which dissolves the oxide to form ammonium molybdate. Copper oxide forms an objectionable constituent because it also dissolves and reappears in the subsequent evaporation of the ammoniacal solution. Evaporated to crystallization, preferably under reduced pressure, so-called ammonium molybdate crystallizes out from the filtered solution. This contains 81.55 per cent of molybdic oxide, 8.27 per cent ammonia and 10.19 per cent water. On ignition ammonia is driven off and molybdic oxide results. A previously mentioned process whereby the oxide is won by volatilization directly from the ore, may be referred to here.

"When the oxide is heated in a wind furnace which is carbon in graphite crucibles a dark powder results which is commercial molybdenum. An analysis of such a

product showed 95 per cent molybdenum and 2 to 3 per cent carbon combined by cementation. The metal forms carbide readily. With care a product may be made 99 per cent pure.

"Among the early manufacturers Sternberg and Deutch in 1892 made a metal which contained 3 per cent carbon by igniting precipitated calcium molybdate, in similar fashion, with carbon. Their factory was situated near Berlin and the capacity was 200 kg metal a day. The admixed calcium oxide was leached out of the metal with hydrochloric acid. The metal at that time brought 86½ cents a pound. It contained 3 per cent carbon.

"Moissan first introduced the use of the electric furnace. By heating ammonium molybdate he made the dioxide which he treated with 10 per cent pure carbon. The resulting metal contained carbide.

"Guichard produced a metal of high carbon contents directly from the sulphide in the electric furnace. The ore, nearly pure molybdenite, gave a metal of 91.5 per cent molybdenum contents. Current used, 300 amp., 50 volts.

"Robert Keeney of the Colorado School of Mines found that either the raw or roasted ore can be used in making ferromolybdenum in the electric furnace. Lime is used as a fluxing and desulphurizing agent. Ferric oxide is subsequently added for decarbonizing purposes. In the case of direct use of molybdenite the sulphur slags off in form of calcium sulphide. With a current of 900 amp., 50 volts, sulphur is found to be entirely expelled from molybdenite. However, about 7 per cent of carbon is absorbed, partly graphite. This can be reduced by the decarbonizing action of freshly added oxide. Wulfenite when fluxed with sodium carbonate gives oxide of lead and sodium molybdate. The latter is soluble in water; the former is not. From the solution the oxide can be gotten and worked into metal. Such mention seems necessary now since Wulfenite in 1914 found a good market at 60 cents per pound of MoO₃ contained in good grade concentrate.

"The thermit or aluminothermic process, which depends upon the greater heat of formation of aluminum oxide for reduction, produces a high-grade metal free from carbon. Ninety-eight to 99 per cent of molybdenum and the remainder iron is the composition of the product.

Porcelain

Constitution of Porcelain.—The results of a study of porcelains made at the Bureau of Standards is given in the *Journal* of the Washington Academy of Sciences by A. A. KLEIN. A more detailed account will appear later as a Technologic Paper of the Bureau of Standards. Bodies and mixtures of kaolin, feldspar-kaolin, feldspar-quartz, and feldspar-clay-quartz were burned at various known temperatures and examined microscopically. Kaolin appeared homogenous when heated up to 1200 deg. As the temperature is increased from this point dissociation begins, at first slowly, then at an increasing rate, until at 1400 deg. dissociation is complete. The products of dissociation were found to be silica and aluminium silicate, the latter being identified as an amorphous phase of sillimanite.

"Up to 1340 deg. in mixtures of quartz and feldspar the quartz dissolves to only a small extent in the feldspar glass. At 1460 deg. the quartz is practically completely dissolved in specimens having as high a quartz content as 50 per cent quartz to 50 per cent feldspar.

"In specimens containing kaolin and feldspar the kaolin dissociates entirely at 1340 deg. The amount of crystallized and amorphous sillimanite increases with an increased content of kaolin, at least to a concentration of 50 per cent kaolin to 50 per cent feldspar.

"At 1460 deg. apparently 10 per cent kaolin is entirely soluble in the feldspar glass. With higher concentrations of kaolin the amount of crystallized sillimanite increases. The needle crystals are well developed and comparatively large.

"At 1310 deg., in quartz-clay-feldspar bodies, the feldspar is present as a glass; the clay shows almost complete dissociation with the formation of amorphous sillimanite mainly and but little crystallized sillimanite, while the quartz is undissolved and the grains may still be of considerable size, up to 0.2 mm., or more, depending upon the fineness of grinding.

"By burning these bodies at 1380 deg to 1400 deg. the feldspar glass dissolves considerable quartz, there being only a comparatively small amount of residual quartz remaining. The quartz grains are much rounded and etched and they seldom show a length over 0.06 mm. The clay is dissociated with the formation of crystallized sillimanite, although an extremely small amount of amorphous sillimanite may be present.

"The changes involved by burning commercial bodies are identical with those of laboratory prepared bodies. The quartz grains observed in whiteware and in low-fired vitreous ware are large and angular, showing a size of 0.2 mm., or more, whereas in the hard porcelains, due to solution, the quartz grains are rounded and etched, and seldom exceed 0.05 mm. in length.

"The constitution and the microstructure of porcelain depend upon the temperature of burning, and change as this temperature changes. This has served as a basis for the estimation of the probable burning temperatures of the commercial bodies, a fact which was accomplished with success, the error involved being within 25 deg. It appears that the time-of-burning factor is by no means as important as that of the burning temperature in determining the constitution and microstructure of the ware.

"No cristobalite or tridymite has been definitely observed in any of the laboratory or commercial bodies examined. It appears that the quartz dissolves in the feldspar glass more readily than it inverts to the other modifications of silica.

"In conclusion, it may be stated that the petrographic microscopic study of porcelain has led to interesting and, it is to be hoped, important technical results. It has placed the chemical and physical processes involved in the formation of porcelain on a more quantitative thermal basis. Furthermore it has offered a means of estimating the burning temperature of a ware by an examination of a fragment much too small in size to be satisfactory for even a chemical analysis."

Oxygen

Blasting with Liquid Oxygen in Salt Mines.—Some interesting data on this method of blasting which has been advanced by the war are given in *Engineering* (London) for Sept. 22, 1916. In experimenting with the process cartridges were charged with charcoal and the carbon impregnated with liquid oxygen. The ignited carbon then burned with explosive energy. Great difficulties were encountered as liquid air does not admit of being stored in closed vessels and evaporates rapidly in open vessels. In 1915 experiments with liquid oxygen cartridges were energetically taken up by the salt works at Winterhall, acting in conjunction with the famous potassium salt mines of Stassfurt and other localities, and considerable progress has been achieved, according to an illustrated article by Dr. Heberle of Berlin, published in the journal *Kali* of Jan. 15 and April 15, 1916. The cartridges are simply made of texture, paper, or cardboard and are charged with soot or charcoal, mixed sometimes with other ingredients, or with kieselguhr

and petroleum. The soot has answered well. A cap of fulminate of mercury is generally added for ignition; this cap should not be rigidly connected with the cartridge, to facilitate impregnation of the carbon. The Marsit cartridge does not need any cap. Ignition is by fuses or by electric wires. Dr. Hecker is said to have devised suitable ignition devices which do not require the instantaneous ignition of all the cartridges in a circuit. Impregnation of the precooled material may be effected either by pouring the oxygen into the cartridge through a tube of filter paper (Baldus and Kowatsch), or by immersing the cartridge in the liquid; the latter procedure is preferable. The oxygen should be of high concentration, 99 or 97 per cent. The immersion of a cartridge takes from 5 to 25 min. The experiments seem, at any rate, to have established several important facts. A cartridge can be so impregnated that it will still explode 10 or 15 min. after being tamped in its hole; means have even been found by which cartridges could be impregnated at the surface and be taken down and used as much as three hours later. This is not considered important for salt mines, because the general conditions there demand that many appliances should be kept below. But the fact that not more than two men are required to look after up to twenty blasts would be important. Glass vessels or bottles were first tried for the transport of the liquid oxygen; but some unpleasant experiences were met with, and the transport vessels and immersion vessels are better made of metal. A hole may require 2 liters of liquid oxygen. The immersion cylinders at Winterhall have a diameter of 25 cm. and 38 cm. height; but big cartridges, 32 mm. in diameter, are sometimes used, and as many as five cartridges are fixed in one hole of a depth of 150 cm. This great depth of the bore-holes is characteristic of salt blasting. Heberle estimates that one blast would cost 14s., counting materials and labor. That would not be cheap, and, he adds, moreover, that conditions may be less favorable elsewhere than they are at Winterhall. The actual dearth of explosives during war time may be a factor in these attempts. But there has been a good deal of experimenting on oxygen cartridges in England as well, of course, and the point is to adapt the extra plant to the special conditions and to utilize it fully. Sawdust, we see from another German publication on mines, has not answered well as an absorbent for oxygen in cartridges, and it was observed in a limestone quarry that the percentage of carbon monoxide present in the air went up to 0.15 after firing two of these shots. That would be a grave matter.

Recent Chemical and Metallurgical Patents

Copper, Lead and Zinc

Wet Copper Process.—A method for the extraction of metals from ores has been patented by HENRY B. SLATER of Riverside, Cal. The principle involved is to subject the ore containing the metal (copper) to the action of a solution containing alkali metal chloride, and a metallic chloride capable of reduction to a lower chloride, together with hypochlorous acid, then precipitating the copper from solution and subjecting the solution to the action of free chlorine in the presence of a metallic hydroxide to regenerate the solution containing hypochlorous acid together with a metallic chloride capable of reduction to a lower chloride for use in a cyclic process. To convert the metal value into chloride, sodium chloride is used. Hydrochlorous acid and ferric chloride are the reducing agents employed. A calculated amount of sodium hydroxide is then added to precipitate the iron in solution, and further additions of sodium hydroxide made will then precipitate the copper in the

hydroxide form. The solution containing the reducing agents is regenerated by adding free chlorine to the liquor in the presence of enough iron hydroxide to give ferric chloride. The copper hydroxide obtained is filtered, washed and pressed into slabs which have an iron mesh work in the center. These slabs are used as cathodes in an alkaline electrolyte, usually sodium hydroxide, after having been dried and heated to 600 deg. C. in a muffle furnace. The hydrogen liberated during electrolysis serves to reduce the copper oxide on the cathode, and, it is claimed, gives a very pure product. 1,195,616, Aug. 22, 1916.)

Leaching Process.—HENRY B. SLATER of Los Angeles, Cal., has patented a process of making a leaching solution for the extraction of metals from their ores. Briefly, it consists in subjecting a solution of ferrous chloride and sodium chloride to electrolysis in the anode compartment of an electrolytic cell, and simultaneously subjecting a solution of sodium chloride to electrolysis in the cathode compartment of the same cell. The two solutions are kept separated by a porous diaphragm. This diaphragm should be of such a permeability as to permit the cathode products to diffuse through it. The electrolysis should be maintained after all the ferrous chloride has been converted to the ferric compound, so as to permit the formation of hypochlorous acid by the reaction of the chlorine set free in the anode compartment and the diffusion products from the cathode compartment. The patent gives an illustration of the type of cell to be used. (1,195,617, Aug. 22, 1916.)

Fused Electrolysis Under Pressure.—A patent has been granted to ROBERT J. MCNITT of Perth Amboy, N. J., for a method of reducing metals. The principle employed is to reduce the fused metallic compounds by means of electrolysis and to raise the boiling point of the metals to be extracted by means of pressure applied to the molten electrolyte either artificially or by the gases produced during the process. The temperature of the electrolyte must be kept below its boiling point at atmospheric pressure. An illustration of the type of cell to be used is given in the patent. (1,197,137, Sept. 5, 1916.)

Electrolytic Cell.—WILLIAM E. GREENAWALT of Denver, Col., has patented the electrolytic cell, shown in Fig. 1 in longitudinal section, in Fig. 2 in plan, and in Fig. 3 in transverse section. Fig. 4 is a detail section of the preferred construction and Fig. 5 is the corresponding plan. In the figures, 1 is a tank containing the electrolyte in which is suspended the electrode cell

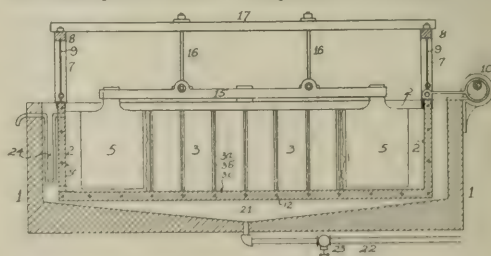


FIG. 1—ELECTROLYTIC CELL

2, by the flexible suspenders 9, from the beams 8, supported by the posts 7. The anode bell is oscillated by some mechanical means 10. The electrode bell is constructed by bolting diaphragms 3 to the pieces composing the sides of the cell 4. The diaphragms themselves are made of mullioned frames, between which is supported the diaphragm fabric; 5 represents the anodes, bolted together by the bar 15, which may act

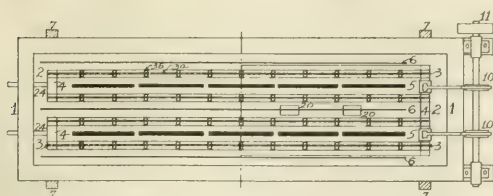


FIG. 2—ELECTROLYTIC CELL

as a conductor for the current. The anodes are suspended by the rods 16, from the beams 17. The cathodes are indicated by figures 6, and are suspended by rods 18 from the beams 19. The rate of oscillation will vary with the current density from 20 to 60 oscillations per minute. Openings 20 are placed in the bottom of the cathode compartment so that any non-adherent material may be worked through them by the oscillating cell into the bottom of the electrolyte tank 21, and then removed from time to time through the pipe 22 and valve 23. Similarly, the non-adherent anode material may be eliminated from that compartment by the oscillating electrode cell and the duct 24.

In the "preferred construction," both the anode and cathode compartments are bolted together and oscillate in the electrolytic tank. In this manner both the anolyte and the catholyte are thoroughly agitated and as the catholyte passes through the diaphragm into the anode compartment and is then exhausted by the duct 24 there is little chance for the ferric compounds, which usually are present in the electrolysis of copper solutions, getting back to the cathode and reducing the current efficiency, either through impoverishment of the electrolyte at the electrodes or by useless oxidation and reduction. In some electrolytic processes, as for example in the electrolysis of copper solutions with graphite or magnetite anodes, the diaphragm fabric may be omitted. The mechanical action of the apparatus is however maintained. In this case the fabric supporting frames, including the mullions or cross-pieces will act as agitators for the electrolyte, and this improves the electrolytic action. (1,186,898, June 13, 1916.)

Iron and Steel

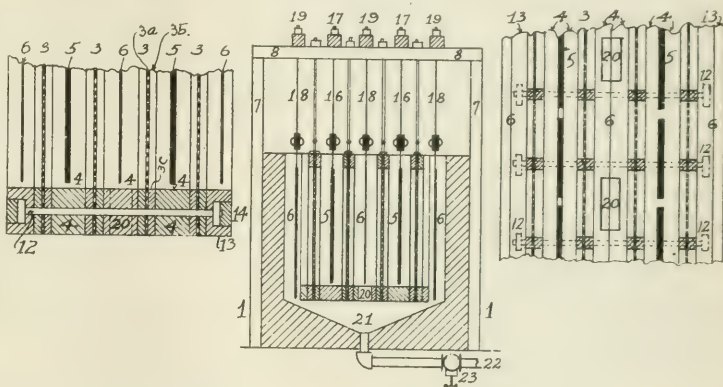
Untarnishable Iron Alloy.—An alloy which is useful for cutlery owing to its non-tarnishing properties is patented by HARRY BREARLY of Sheffield, England. It consists of iron containing between 9 and 16 per cent of chromium and less than 0.7 per cent of carbon. A typical composition is carbon 0.30 per cent, manganese 0.30 per cent, chromium 13.0 per cent and the balance iron. Small amounts up to 1 or 2 per cent of nickel, copper, cobalt, tungsten, molybdenum and vanadium appear to be without effect on the untarnishable properties. (1,197,256, Sept. 5, 1916.)

Soldering Composition.—A composition for soldering cast iron, mild steel, aluminium, etc., is patented by WILLIAM A. DAY of Bellingham, Washington. The

alloy consists of twenty-five parts lead, twenty-five parts tin and fifty parts zinc. The articles are prepared for soldering by cleaning and then covered with stearic acid or similar flux and the alloy is applied with an extra hot soldering copper. (1,195,955, Aug. 22, 1916.)

Electrolytic Process of Removing Rust.—An electrolytic process of removing rust or oxide from iron or steel in which the object to be treated is made the cathode in an electrolyte containing phosphoric acid, is patented by PASCAL MARINO, of London, England. The electrolyte is made up by adding ten parts of phosphoric acid to ninety parts of water or by adding 10 per cent of phosphoric acid to a 10 per cent solution of sodium phosphate. A temperature of 50 to 70 deg. C. is used. (1,195,704, Aug. 22, 1916.)

Steel and High-Phosphorus Slag.—A method of producing steel and high-phosphorus slag which can be used as a fertilizer is patented by ANSON W. ALLEN and EUGENE G. LILLY, of Birmingham, Ala. The method is an adaption of a process described in an application of



FIGS. 4, 3, 5—ELECTROLYTIC CELLS

William R. Walker, Oct. 7, 1914, No. 865,504. An example of the process as worked on Birmingham, Alabama, metal is as follows: The Birmingham pig iron running 0.8 to 1 per cent in phosphorus and about 0.8 per cent silicon is first blown in an acid Bessemer converter, the silicon helping to form a very fluid blown metal from which the slag can be thoroughly separated. The blowing is continued until the silicon is practically all removed and a large part of the carbon and manganese are also removed, leaving a high phosphorus blown metal. This is then separated as completely as possible from the slag and transferred to the second or roughing down furnaces.

The roughing down furnaces, as well as the finishing furnaces used are of the regenerative gas-fired open-hearth tilting type. The roughing down furnaces are basic lined for the removal of the bulk of the phosphorus from the blown metal to produce what is called duplex metal and the high phosphoric slag. The third furnaces are of the open-hearth regenerative gas-fired type, either tilting or stationary and either acid or basic lined according to the specifications of the steel to be made.

The roughing down furnaces are first charged with the necessary amount of lime and iron oxid to oxidize and carry into the slag the phosphorus contained in the blown metal. When a sufficient quantity of the blown metal has been charged and the slag is fluid and found to be of the right composition a measured quantity, say

mium is dissolved than the current can deposit, it is necessary to maintain the electrolyte acid.

The refined cadmium deposit is stripped from the copper cathodes, or, if cadmium cathodes were used, is melted directly under sodium hydroxide or paraffin and cast for marketing. The anode sludge contains quite a large amount of cadmium. It is therefore remelted, cast into anodes and again subjected to electrolysis. The sludge obtained from this second refining will be comparatively low in cadmium and high in copper, bismuth and lead.

To obtain the bismuth, the sludge from the second refining process is melted and cast into anodes, and electrolyzed in a bath containing bismuth sulphate, sulphuric acid and a soluble salt of sulphocyanic acid, preferably an alkaline sulphocyanate, together with sufficient glycerol to clarify the electrolyte. As cathode, copper is employed. Electrolysis is conducted at approximately 0.4 volts and 3 amperes per square foot. In this manner the bismuth is obtained in a pure state.

The patent describes the application of this process on bag house dust in detail, giving the chemical equations involved in the course of procedure. (1,194,433, Aug. 15, 1916.)

Mercury.—A patent has been granted to WILLIAM H. LANDERS, of New Almaden, Cal., for the apparatus shown in Fig. 7 for the recovery of mercury. A is a multiple-hearth furnace, the circulating air being received at 14; 20 is the flue through which the gases containing the mercury vapor leave the furnace and enter the dust-settling chamber B. This chamber has the double object of keeping the vapors sufficiently hot to prevent any precipitation or condensation of the mercury and to reduce the velocity of the gases entering it. The latter is accomplished by making its cross section large in respect to the opening at 21. Decreasing the velocity of the gases permits the settling out of the dust. The outlet passage 23, at the top of the dust-settling chamber, leads to the bottom of the condenser chamber C. This condenser chamber consists of a number of collecting chambers or trays 24, in a base 25 connected by a series of pipes 25. The last chamber connects with the stack. Between and around the pipes 25 are the baffles 27, which form the space for the circulating cooling air, which is supplied by a fan D. The fan as connected serves the double purpose of cooling medium and, due to the heat abstracted from the gases carrying the mercury, as an agent for increasing the velocity of the gases in the stack. The latter creates a suction through the whole system and thus serves to remove the gases formed in the furnace very effectively. In a separate illustration in the patent a device is shown, by which a final condensation of the mercury may be effected after passing the condenser chamber. (1,195,236, Aug. 22, 1916.)

Aluminium

Soldering Aluminium.—A soldering compound to be used in soldering articles of aluminium is patented by

FRANCIS E. J. LITOT, of Wilkinsburg, Pa. The compound consists of 100 parts zinc and 1 to 10 parts phosphor tin. The smaller the proportion of phosphor tin present the greater will be its enduring qualities, but the higher its melting point. The best joints are made with 100 parts zinc to 1 part phosphor tin, which gives a sufficiently low melting point to prevent overheating of the aluminium. (1,194,648, Aug. 15, 1916.)

Composition for Welding and Soldering Aluminium.

—A low melting composition of metals for welding and soldering aluminium is patented by ROBERT L. WEATHERFORD, of Fort Worth, Texas. The composition consists of one part aluminium, one part lead, two parts tin, two parts zinc, one part bismuth and one part antimony. The ingredients are melted and thoroughly mixed by agitation, and treated five times with 66 per cent sulphuric acid. Two parts of acid to one of alloy are used, the function of the acid being to cleanse the alloy, just before being molded. After it has evaporated it leaves the dirt and sediment floating on the surface. The following instructions are given for use: "The article to be welded or soldered should first be freed from all dirt and obstacles by brushing the ends to be welded or the surface to be soldered with a steel brush. The parts so cleaned are then subjected to heat with an ordinary gasoline blow torch equal to about 800 deg., at which time the said compound is applied under the heat,

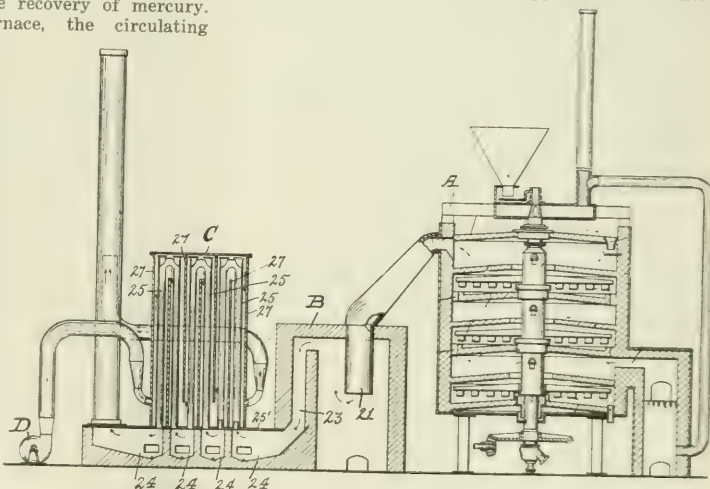


FIG. 7—APPARATUS FOR RECOVERING QUICKSILVER FROM ITS ORES

which causes it to become soft and doughy when it is worked into desired shape to correspond with the ends being welded, after which the work is allowed to cool and is ready for use." An advantage is claimed on account of the low heat used in comparison with the acetylene process which tends to weaken the aluminium through crystallization. (1,194,101, Aug. 8, 1916.)

Miscellaneous Processes

Hydrogen Peroxide.—A process for the manufacture of hydrogen peroxide is patented by FABRICIUS COBELLIS, of Philadelphia, Pa. The process consists in electrolyzing a solution of ammonium sulphate containing 3 lb. to the gallon to which is added 3 lb. of sulphuric acid (strength not given). A platinum anode and lead cathode is used, and the temperature kept below 60 deg. Fahr. The electrolysis produces a persulphate of ammonia and after a certain time the solution

is drawn off, placed in an autoclave, with the addition of 6 lb. of ammonium bisulphate per gallon, and subjected to a pressure of 100 lb. and a temperature of 280 deg. Fahr., when the hydrogen peroxide is formed. It is then cooled to 150 deg. Fahr. and a vacuum applied, the hydrogen peroxide now distilling over. Dry air or another inert gas is passed through the solution during the distillation. (1,195,560, Aug. 22, 1916.)

Process of Purifying Sewage.—An electrolytic sewage purification process in which the solids and liquid are first separated and then treated separately is described in a patent of DANIEL T. DOBYNS and JAMES K. ELDERKIN, JR., of Newark, N. J. The process consists in adding milk of lime to the raw sewage, agitating and allowing it to settle. The milk of lime precipitates the solids or sludge and the liquid is conveyed to an electrolyzer where it is oxidized by electrolysis. The separate solids are electrolyzed with the addition of sodium chloride solution in a separate electrolyzer. Sodium hypochlorite and oxygen are formed in electrolyzing the sludge and the purifying action of which is well known. (1,194,000, Aug. 8, 1916.)

Removing Drilling Tools from Oil and Gas Wells.—According to a patent of WALTER O. SNELLING of Pittsburgh, Pa., drilling tools which have become broken and jammed in drilling wells, may be removed by introducing a salt solution, lowering a copper bar until it makes contact with the iron drill and then passing a current of 300 to 400 amp. through the electrolyte. The nascent oxygen formed corrodes the iron, and this corrosion may be carried so far as to completely consume the tools, or only partial corrosion may be carried on, when the tools become dislodged and may be fished out. (1,196,819, Sept. 5, 1916.)

Electric Zinc Distilling Furnace.—An electric furnace and condenser for the distillation of impure metals which can be practically volatilized is patented by JOHN THOMSON, of New York City. The furnace is described in connection with zinc distillation. It consists of a trough to contain the bath of molten metal, a zig-zag resistor suspended horizontally above the trough, and a roof composed of spaced plates above the resistor. The fumes escape through these plates and they also serve to radiate most of the heat from the resistor downwards onto the bath. The construction of the resistor is one of the main features of the patent. It is made up of zig-zag plates in the manner originally proposed by F. A. J. Fitzgerald ("Electrochemical and Metallurgical Industry," 1905, page 215). A carbon bar or slab is cut partially through, alternately from one side and then from the other, producing a zig-zag circuit of limited cross sectional area. The condenser connected with the furnace consists of a series of baffle plates so arranged as to cause the fume to flow back and forth, while progressing constantly forward. The condensed metal forms a bath in the condenser over which the uncondensed fume flows. The condenser may be heated by resistors in order to keep the temperature above that at which dust forms. A dust condenser may be operated in conjunction with the furnace and liquid condenser, the dust condenser taking any surplus fume. (1,193,633, Aug. 8, 1916.)

Nitrogen Products

Production of Oxamid.—A process for the production of oxamid (CONH_2), from cyanogen and hydrochloric acid is patented by JOHN E. BUCHER, of Coventry, R. I. (assigned to the Nitrogen Products Company, of Providence, R. I.). The object of the process is to produce oxamid to be commercially used as a fertilizer. It was announced by von Liebig in 1860 (Ann. 113, p. 246), that oxamid could be produced from cyanogen and aldehyde, and in 1867 by Schmitt and Glutz (Ber. 1, p. 66) that oxamid could be produced from cyanogen and hydrochloric acid, but nothing has been done since then to produce oxamid commercially. It is proposed in the present patent to conduct gaseous cyanogen liberated from a cyanogen compound, into concentrated hydrochloric acid, the temperature being maintained low enough to prevent the formation of oxalic acid. The hydrochloric acid acts catalytically to combine the water and cyanogen into oxamid. Water is added from time to time as it is used up. (1,194,354, Aug. 15, 1916.)

Rotary Pump

A rotary pump which is finding considerable use in handling the wash oil, tar, and ammoniacal liquor from by-product ovens owing to its positive delivery and ease of starting and stopping is shown in the following illustrations. The pump is a product of the P. H. & F. M. Roots Company of Connersville, Ind., manufacturers of pumps and blowers.

The operating principle of the Roots' rotary pump is very simple. The moving parts consist of two parallel shafts with an impeller on each and each having a gear keyed on the end. They are assembled at 90 deg. one to the other, and this relation is permanently maintained by means of the previously mentioned gears. Fig. 2 shows a view of the pump with the head plate removed, and Fig. 1 shows an assembled view. The impellers rotate in opposite directions. The suction pipe water is inclosed between the impeller (as shown in vertical position) and the case so that for an instant there is a body of water which is not open to either the suc-

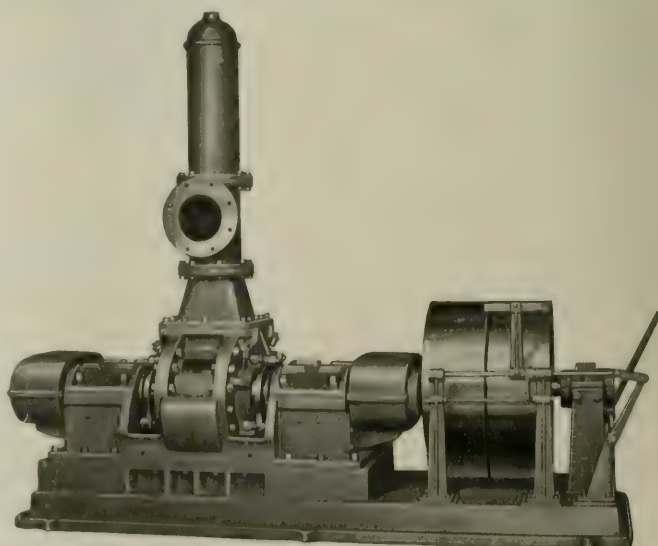


FIG. 1.—VIEW OF ASSEMBLED PUMP AND DRIVE

tion or discharge sides. As the impeller continues to rotate, it immediately opens to the discharge side, and the volume which was inclosed is forced into the discharge side. Since, owing to the shape of the impellers, there is at no time a possible return between the shafts, it is evident that a quantity of water equal to the inclosed volume is discharged at every half revolution of each impeller. For each revolution of the pump, therefore, four times this volume is discharged.

The impellers are of steel, forged integral with the shaft. This design gives great rigidity, obviating vibrations, so harmful to

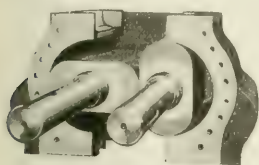


FIG. 1—PUMP WITH HEAD PLATE REMOVED

gears, stuffing boxes and bearings, and eliminates a pressed and keyed fit between the impeller and the shaft. The removable cast-iron tips may be changed without dismantling the machine. The case is composed of two identical semi-circular castings and two identical headplates, all ribbed to eliminate deflection. They are of homogeneous, close-grained gray cast iron. Suction air chambers are cast in the lower part of the case.

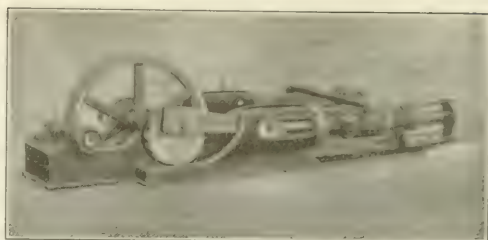
The bearings are approximately three times the diameter of the shaft which, since the shaft is of ample proportions, gives a very low bearing pressure. This together with profuse oiling maintained by oil chains or rings reduces wear to a minimum. Since practically all of the wear occurs vertically the single wedge beneath the lower half box permits adjustment at any time, if necessary, while the pump is in operation. In the pumps of large capacity the expense of a quarter box bearing is justified, owing to the greater nicety of adjustment thus made possible and which becomes necessary on the larger sizes. The main bearings are cast integral with the headplates, and the pump is self-contained on a deep well ribbed bedplate.

As these machines have their most common application for pumping water and non-corrosive liquids, cast iron and steel are commonly used, as previously described. In case the liquid to be handled is corrosive, suitable resisting metal is selected. Designs have been made for three ranges of pressures: low-lift pumps for heads from 0 to 30 ft.; medium-lift pumps or heads from 30 to 80 ft., and high-lift pumps for heads from 80 to 200 ft. Capacities vary from a displacement of one-tenth of a gallon per revolution up to 50,000 gal. per minute.

A Motor-Driven Four Plunger Horizontal Hydraulic Pump

The hydraulic pump illustrated by the accompanying photograph is a recent addition to the high-pressure hydraulic pumps built by The Hydraulic Press Manufacturing Company, Mount Gilead, Ohio. It is of the horizontal, four-plunger type and designed to fill the requirements for a simple, heavy-duty hydraulic pump for applying a large volume of water or other fluid against a high pressure.

The pump is designed so that it may be equipped with sixteen different sizes of plungers ranging from 1½ in. to 5 in. in diameter, advancing by quarter inches. The water cylinders are made of forged steel for the highest pressures. For the medium pressures, 1500 to 2900 lb. per square inch inclusive, cast steel is used, and for the lowest pressures the cylinders are semi-steel. The pressures range from 9500 to 700 lb.



CLASS "O" FOUR-PLUNGER HORIZONTAL HYDRAULIC PUMP

per square inch, and the water capacity from 24 to 326 gal. per minute. All sizes have bronze valve seats and bronze or nickel steel valves. The pump is built for motor drive and requires 150 hp. to operate. It is equipped with a flexible shaft coupling for motor connection. Any 150 hp. motor having a speed of from 450 r.p.m. to 750 r.p.m. may be used. The speed of the crank shaft is 60 r.p.m., and the stroke of the plungers is 16 in., the two cranks being set at 90 deg., so that a uniform flow of fluid may be obtained.

The pump was designed so as to be especially adapted to long service. At all points where the strain and wear is most severe, the parts such as main bearings, connecting rod ends, cross head guides, valves and valve seats, are of easy access for adjustment and replacement. The frame or pump bed consists of two heavy castings bolted together. The cross head guides and main bearing containers are machined in this frame. The pump occupies a floor space 18 ft., 8 in. in length by 6 ft. 10 in. in width. The illustration shows the pump equipped with a spur gear and pinion, but it may also be equipped with a herringbone gear and pinion.

The Empire Concentrating Table

In the field of coarse concentration with high capacity, it is essential, if a table concentrator be used, that the stroke of the table be long and that the flow of the water over the table be such, as to prevent banking of the sands. These two features, it is claimed, are embodied in the Empire concentrating table, shown in Fig. 1.

While this table treats material ranging from ¼ in. to zero, its main field of application lies in treating the coarser material. The length and number of strokes depend on the size of the material treated, the strokes varying from 110 to 135 per minute, and the range of the length lying between 3 to 6 in. The head-motion is simple, eccentrically driven and positive in motion. The riffles are in channel form, made of a non-corrosive metal. The channel riffle gives an additional saving in the fine material within the riffle itself, which is not the case with the ordinary solid type of riffle.

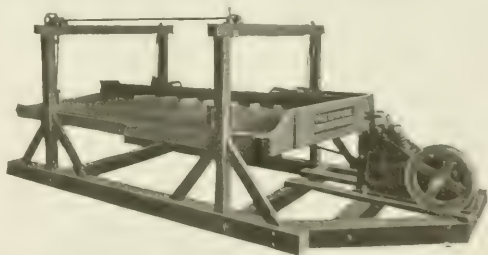


FIG. 1—THE EMPIRE CONCENTRATOR TABLE

If, on an ordinary Wilfley table, $\frac{1}{4}$ -in. material were treated the sands would bank along one line, due to the method of irrigating this type of table. In the Empire table a series of adjustable deflectors are employed, which give a peculiarly retained current to the wash water. This action makes it possible to use a long stroke with a large capacity. The length of stroke may be changed during operation by means of a hand-wheel, located at the head-motion. The tilting of the deck is regulated by a similar wheel at the discharge end of the table.

The deck is suspended in such a manner as to raise it vertically for a short distance on the forward stroke. The mechanism used in giving the table-motion produces a retarding effect at the end of the forward stroke and an accelerated effect at the beginning of the return stroke. The combination of the effects mentioned, together with the dropping away of the deck from the ore-bed on the return stroke, result in a jiggling and panning motion. It is thus seen, that jiggling in a separate machine may be eliminated with the use of this table.

The space occupied by a table is 5 ft. 2 in. by 12 ft. 7 in. The capacity per table is 35 to 50 tons of 30-mesh material per day and larger tonnage with coarser material. The water consumed per table varies from 10 to 12 gal. per minute. The power required per table is $\frac{1}{4}$ to $\frac{1}{2}$ hp. The table ready for shipment weighs 1300 lb.

Some of the advantages claimed for the table are: large capacity, clean concentrates, clean separation of the various minerals, clean tailings, replacement of the jig, small floor space occupied, simplicity of construction and manipulation, low power and water consumption and low costs of installation and operation. The table has been in successful operation in the Idaho Springs District, Colorado, and is built by The Empire Concentrator Company of Denver, Colo.

Modified Assay Furnace

In the accompanying illustration, Fig. 1, is shown a Bosworth assay furnace so altered that it will burn anthracite coal instead of coke, thereby reducing fuel consumption. The alterations have also resulted in increasing the capacity and facilitating repairs.

The ash-pit of the standard Bosworth has been replaced by a brick one of considerably larger dimensions, with a grate at the top to support the fuel, and with an iron ash-door in front of convenient size. Below the ash-pit was placed a $\frac{1}{2}$ -in. iron plate, projecting 18 in. in front. This plate makes a safe bed for the ashes to fall upon, and the projecting shelf a convenient and fire-proof place for slag molds and hot crucibles. The whole furnace may be safely supported on brick piers, as shown, or heavy pieces of timber. The piers are built up to such a height as to elevate the muffle to a position convenient for charging and uncharging. The compartment containing the draft-door has been left unchanged. The capacity of the furnace was increased by chipping out the muffle arch and replacing the standard-sized muffle with a larger one. Two muffle supports have been built into the rear of the furnace, replacing the one usually supplied, and so increasing the life of the muffle. Using a larger muffle leaves a space of only 2 or 3 in. between the muffle and the inside furnace walls, but this is sufficient for the anthracite fuel used. The hole in the top of the furnace has been enlarged, giving a better draft, and over this hole a permanent brick chimney was built. The entire weight of this chimney is supported by rods from the ceiling. This adds to the life of the furnace and facilitates furnace repairs,

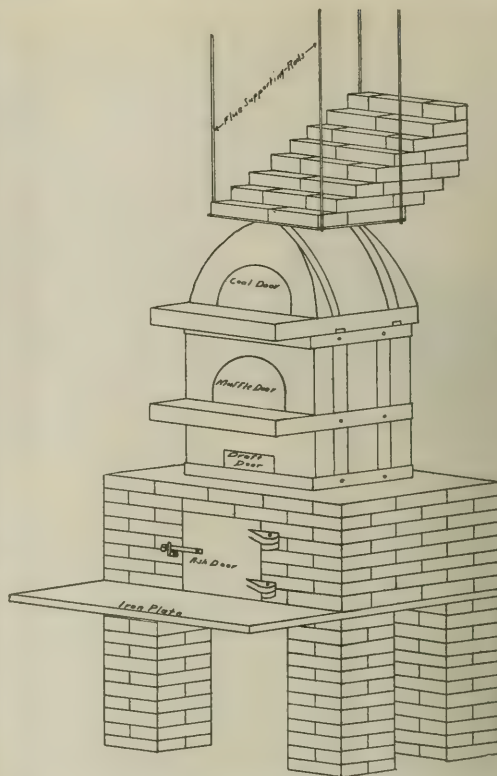


FIG. 1—IMPROVED ASSAY FURNACE FOR ANTHRACITE COAL.
SCALE 1 IN. = 1 FT.

as the entire furnace may be removed without disturbing the chimney. The joint between the chimney and furnace is simply luted with fire clay.

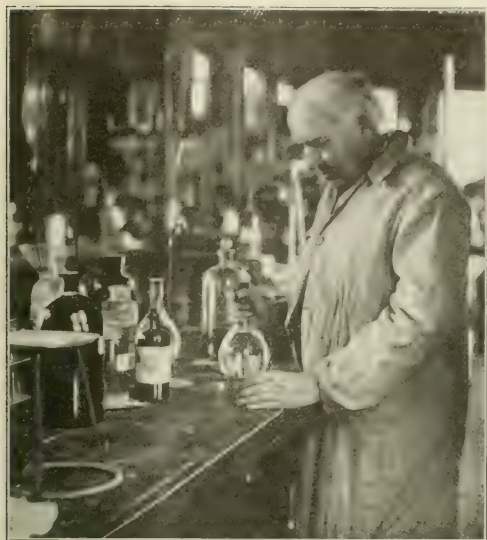
In starting the furnace, kindling and one bucket of coal are used. When this coal is well fired a second bucket is added, and by the time the whole mass is red, the furnace has attained a high heat, which it will hold for some hours, giving sufficient time for the fusion of a number of charges. This furnace is especially adapted to the needs of a custom assayer whose daily runs fluctuate considerably.

The above furnace has been designed by J. E. Dollison, of Alma, Colo., and is used by him in his custom assay office at that place.

Book Review

Canadian Trade Index. Issue of 1916-1918, 560 pages. Price, \$5.00 net. Toronto, Canada: The Canadian Manufacturers' Association.

This book corresponds to our directories of manufacturers and aims to provide buyers of Canadian manufactured goods with a dependable list of the articles made in Canada and the names of the manufacturers. Canada is growing, as evidenced by the fact that between 2000 and 3000 new names have been added since the last edition. The book is nicely arranged and contains both an English and French index of articles, together with an alphabetical list of manufacturers for ready reference.



TWO RECENT PHOTOGRAPHS OF THOMAS A. EDISON IN HIS CHEMICAL LABORATORY

Personal

Mr. George A. Burrell, at present consulting chemical engineer and president of the Natural Gas Products Company of Pittsburgh, Pa., was in Louisiana this month making tests of natural gas for gasoline content with the view of installing absorption plants. The Natural Gas Products Company uses an absorption process, worked out by Mr. Burrell, who was formerly in charge of natural gas, gasoline, gas investigations, and other research work for the Bureau of Mines. He was tendered a testimonial banquet and presented with a gold watch on Oct. 17 by his colleagues upon the occasion of his resignation from the Bureau of Mines.

Mr. T. C. Desollars, chief engineer of the Quincy Mining Co., Hancock, Mich., attended the American Mining Congress in Chicago.

Dr. Wm. F. Hillebrand, chief chemist of the Bureau of Standards, Washington, D. C., will lecture in Room 309, Havemeyer Hall, on Monday, Nov. 27, 1916, at 4.10 P. M., on "Analytical Chemistry and Its Possible Future." The lecture is one of the Chandler lecture series.

Mr. J. R. Holcomb has been appointed superintendent of the Wilmington Steel Company, succeeding W. J. Stoop, who has resigned.

Mr. Frederick W. Kressmann has severed his connection with the Forest Products Laboratory, Madison, Wis., to become manager of the plant at Fullerton, La., producing ethyl alcohol from wood waste. The plant was originally built by the Standard Alcohol Company and is at present being operated by the Standard Lessee Corporation.

Mr. Thomas Le Clear has resigned as chief chemist of Fraser & Co., of the Chemists Club Building, 50 East Forty-first Street, New York, and is now chief chemist with Marden, Orth & Hastings at Newark, N. J.

Mr. Clarence W. Marsh announces that he has established a New York office at 101 Park Avenue in order to make more available his executive experience in engineering investigations, plant design and construc-

tion for industrial, chemical and electrochemical enterprises.

Mr. Richard K. Meade, chemical, mechanical and industrial engineer, Law building, Baltimore, Md., has been retained by the Hercules Cement Corp. as consulting engineer in connection with the completion and improvement of the plant of the Atlantic Cement Co. at Stockertown, which they have purchased.

Mr. W. E. Mitchell is in charge of the residue-treating plant of the Anaconda Copper Co. at Great Falls.

Mr. William Motherwell, flotation engineer, has left Nelson, B. C., and will be located at Baker, Ore.

Mr. Louis Ruthenberg will be the new general superintendent of the Dayton Engineering Laboratories succeeding W. P. Anderson, resigned.

Professor William Kent Shepard presented a paper on "Physical Tests of Metals" at a meeting of the New Haven Section of the American Society of Mechanical Engineers, held at Sheffield Scientific School, Yale University, Nov. 15. Prof. C. H. Mathewson read a paper on "Applied Metallography."

Mr. Ambrose Swasey, president of Warner & Swasey Company, Cleveland, Ohio, and Dr. John A. Brashear, president of the American Society of Mechanical Engineers, will take an extended trip through Chile.

Dr. Jokichi Takamine and Dr. Alcan Hirsch sailed for Japan on November 23 to aid the Japanese government in building up a dye industry. A dinner in their honor was given on Saturday, Nov. 18, at the Waldorf-Astoria by J. P. Devine of the Buffalo Machinery firm of the same name.

Mr. W. Lee Tanner is chief chemist at the explosive plant of the Bethlehem Steel Co. at New Castle, Del.

Mr. Maurice R. Thompson, formerly superintendent of the electrolytic department of the Chile Exploration Company in Chile, is now with the General Electric Co., as electrometallurgical engineer. His present address is Schenectady, N. Y., but he will shortly go to Salt Lake City.

Mr. W. D. Thornton has succeeded Thomas F. Cole as president of the Greene-Canaan Copper Co.

INDUSTRIAL

Financial and Construction News

Financial

The Aetna Silk Company, Paterson, N. J., has been incorporated with a capital of \$10,000 to deal in silk, wool, etc. Incorporators are Simon Pansy, Solomon Friedman, A. Pansy.

American Chemical Specialty Company, Bridgeport, Conn., has increased its capital from \$10,000 to \$15,000.

The American Coal Mfg. Company, Passaic, N. J., has been incorporated with a capital of \$100,000, to manufacture and deal in chemicals, drugs, etc. Incorporators are A. B. Sinclair, C. G. Francis, E. H. Killheffer.

The American Germicide Corporation has been incorporated with a capital of \$10,000. Incorporators are E. Whiteside, A. F. Barnes, E. H. Shares, 135 West Forty-seventh Street.

The American Paint Products Company, Chicago, Ill., has been incorporated with a capital of \$10,000, to manufacture and deal in paint supplies. The incorporators are L. L. Cowan, B. F. Cowan, R. Montgomery, Chicago.

The Atlantic Dyestuff Company, Boston, Mass., has been incorporated with a capital of \$50,000. Incorporators are M. Reed, T. W. Nelson, T. W. Nason.

The Atlantic Oil & Refining Company, Dover, Del., has been incorporated with a capital of \$1,000,000, to acquire oil lands. Incorporators are N. P. Coffin, C. M. Enger, H. E. Latter.

The Augusta Refining Company, Tulsa, Okla., has been incorporated with a capital of \$750,000. The main office will be in Tulsa.

The Belleville Commercial Foundry, Belleville, Ill., has been incorporated with a capital of \$2,400. Incorporators are F. Rhein, A. F. Weichert, A. Zennert.

Boals Rolls Mfg. Company, Inc., New York City, has been incorporated with a capital of \$10,000, to manufacture medicinal chemicals and drugs, etc. Incorporators are J. R. Boal, and S. and M. Meyers, 302 Convent Avenue.

The Bowe-Burke Mining Company, Duluth, Minn., has been incorporated with a capital of \$50,000. Incorporators are W. W. Bowe, R. L. Burke, H. F. Erickson.

The Bridgeport Steel Company of Bridgeport, Conn., has been incorporated with a capital of \$100,000. The incorporators are C. R. Hall, J. F. L. Hubbard and M. K. Federsch.

The Capitol File Company, Stratford, Conn., has been incorporated with a capital stock of \$50,000. The incorporators are Stephen Moskey, M. F. Moskey, Theo. E. Clark, Benj. J. Moskey.

The Caroune Oil & Gas Company, Pittsburgh, Pa., has been incorporated with a capital of \$1,000,000 to acquire oil and gas lands. Incorporators are J. J. Clark, Bellevue, Pa., J. J. Fawcett, Wilkinsburg, Pa., E. E. Bauer, Pittsburgh, Pa.

Climax Tube Company, Portland, Me., has been incorporated with a capital of \$50,000 to manufacture and deal in all kinds of paper and straw board. The incorporators are B. B. Sanderson, president; E. V. Mann, treasurer; Chas. D. Booth, M. F. Day, all of Portland.

Coldine Chemical Company, St. Louis, Mo., has been incorporated with a capital of \$50,000 to do a general chemical business.

The Continental Industrial Company, Inc., New York City, has been incorporated with a capital of \$5,000 to deal in chemicals, dyes, etc. The incorporators are M. Schneider, J. Ginsburgh, A. B. Stupel, 57 East Ninety-sixth Street.

Crescent Oil, Gas & Gasoline Company, Lexington, Ky., has been incorporated with a capital of \$50,000. Incorporators are J. A. Geary, W. J. Geary, L. L. Shadoin, B. D. Berry, K. D. Wilking.

The Deutschemann Chemical Company, Inc., New York City, has been incorporated with a capital of \$10,000. The incorporators are J. and S. Saens, D. Seigensohn, 201 West 120th Street.

Duristo Paint Company, Inc., Richmond, Va., has increased its capital of \$29,000 to \$99,000.

The Eagle Chemical Works, New York City, has been incorporated with a capital of \$10,000. Alexander Katz of Brooklyn is a director.

The Elifer Foundry Company, Imperial, Cal., has been incorporated with a capital of \$25,000, to convert the Elifer Machine Works into a foundry.

Ekland Tanning Company, Portland, Me., has been incorporated with a capital of \$100,000, to deal in all kinds of materials, including hides, skins, etc. Incorporators are G. L. King, A. E. Pierce, C. L. Donahue.

The Eureka Chemical Company, Inc., Wilmington, Del., has been incorporated with a capital of \$100,000.

The Friars Chemical Company, Wilmington, Del., has been incorporated with a capital stock of \$500,000, to carry on business of chemists, etc. The incorporators are G. E. Fooks, K. M. Dougherty, L. S. Dorsey, all of Wilmington.

The Guarantee Refining Company, Wilmington, Del., has been incorporated with a capital of \$500,000, to acquire and develop mineral lands. The incorporators are F. D. Buck, M. L. Harty, K. E. Longfield, all of Wilmington.

The Ideal Cyaniding Company, Davenport, Iowa, has been incorporated with a capital of \$25,075. Incorporators are A. E. Steffen, A. F. Tanner, A. G. Frick, O. Hill, A. G. Bush. The company will erect a large factory in Arizona or New Mexico.

The Independence Aniline & Refining Company, Independence, Mo., has been incorporated with a capital of \$1,000,000, to manufacture aniline dyes and by-products. The incorporators are A. F. Fonda, Dr. Paul Von Seidenroeder, F. G. Ward, F. C. Adams, I. A. Smith, E. E. Phillips, Z. R. Gurley. Headquarters are in the Martain Building in Independence.

The Interlake Pulp & Paper Company, Appleton, Wis., has been sold to the Consolidated Water Power & Paper Company of Grand Rapids, Wis., for over \$1,000,000. It will be run as a separate organization under the same local management.

McKenna Brothers Sales Corp., New York City, has been incorporated with a capital of \$5,000 to deal in glassware, china, etc. The incorporators are W. L. O'Connell, 231 Edgecomb Avenue.

Massy Bottom Mining Company, Pikeville, Ky., has been incorporated with a capital of \$6,000. Incorporators are I. J. Christie, M. C. Justice, A. J. Yonce.

Marshall Zinc Company, St. Louis, has been incorporated with a capital of \$25,000. Incorporators are E. S. Gatch, B. Burnes, J. M. Blayne, Jr., N. B. Hatch.

The National Sulphur Company, Wilmington, Del., has been incorporated with a capital of \$1,500,000 to mine and extract sulphur. The incorporators are H. E. Latter, N. P. Coffin, C. M. Egner.

The National Type Foundry, Inc., Bridgeport, Conn., has been incorporated with a capital of \$10,000. The incorporators are Geo. S. Platt, Ed. E. Atkins, Wm. J. Platt.

Nats Creek Mining Company, Ashland, Ky., has been incorporated with a capital of \$32,000. Incorporators are L. S. Wilson, S. E. Harman.

The New England Drawn Steel Company, Marlfield, Mass., has been incorporated with a capital of \$210,000. Incorporators are W. B. McKinnon, Wm. McCarthy, and others.

The New Haven Malleable Iron Company, New Haven, Conn., has been incorporated with a capital of \$50,000. Incorporators are C. M. Brennan, E. F. Brennan.

The Nicolet Mining Company, Wilmington, Del., has been incorporated with a capital of \$100,000 to carry on mining and milling business of ores, metals, etc. Incorporators are F. D. Buck, G. W. Dillman, M. L. Harty.

The Ohio-Utah Copper Company, Inc., New York City, has been incorporated with a capital of \$100,000 to mine, mill and concentrate gold and silver, etc. The incorporators are T. Adams, J. L. Friedler, F. Elen, Jr., & Beckman Street.

The Ohio Utilites Company, Wilmington, Del., has been incorporated with a capital of \$500,000 to manufacture artificial gas.

The Perfection Chemical & Mfg. Company, Cleveland, Ohio, has been incorporated with a capital of \$15,000. The incorporators are C. A. Black, C. A. Snyder, A. S. Schneider, W. G. Peterhamel, C. H. Felton.

Pure Gasoline Company, Wilmington, Del., has been incorporated with a capital of \$150,000 to acquire and develop oil and gas lands. Incorporators are W. F. O'Keefe, Geo. G. Steigler, E. E. Wright, all of Wilmington.

The Quaker City Drop Forge Company, Camden, N. J., has been incorporated with a capital of \$150,000. Incorporators are A. J. Glenner, L. Marsh, W. L. Layne.

The Reade Manufacturing Company, 1023 Grand Street, Hoboken, N. J., has been incorporated with a capital of \$20,000 to deal in chemical preparations and medicines. The incorporators are W. J. Reade, J. E. and Chas. H. Reade.

The Republic Oil Company, Wilmington, Del., has been incorporated with a capital of \$3,000,000 to acquire oil lands containing oil, gas and minerals. Incorporators are G. C. Steigler, W. F. O'Keefe, E. E. Wright.

Construction and Operation

Alabama

BIRMINGHAM.—The Semet-Solvay Company, the Alabama Company and Eastern chemists are involved in proposed significant developments in this district. The Semet-Solvay Company, is reported to have purchased 7000 acres of coal lands from the Alabama Company and has acquired iron ore lands in Shades Valley and Ironside. Whether the developments will be carried out by the above companies or a new company formed is uncertain. It is proposed to build a steel plant, several blast furnaces, by-product coke ovens, benzol and other plants. The Semet-Solvay Company has an annual coke production of 1,000,000 tons, and it is proposed to increase this to 1,500,000 tons. The company is capitalized at \$10,000,000.

Arkansas

FORT SMITH.—Charles T. Orr, of Webb City, Mo., will erect a \$200,000 smelter at South Fort Smith. The United Iron Works of Joplin has the construction contract.

California

GRASS VALLEY.—A large addition will be made to the cyanide plant at the Central shaft. The capacity will be doubled, on account of the consolidation of the North Star and Central Mills.

LOS ANGELES.—The Interstate Chemical Company, of Galveston, Tex., is contemplating the erection of a branch plant here to make "dynamine," a compound used in spraying for the eradication of pests. The branch plant will cost \$300,000, and will employ 150 to 200 men. F. Orton is vice-president of the company.

LOS ANGELES.—The Union Oil Company has taken options on several pieces of property near Wilmington, with the probable intention of erecting a refinery to take care of production in the Fullerton district. The company has a refinery in the northern end of the State, but the growth of production in the Fullerton district warrants one in this section.

MARTINEZ.—The Shell Oil Company will add four new distilling units to its large refinery, thereby greatly increasing the output of gasoline and refined oil.

PETALUMA.—The Encore Manufacturing Company, recently organized with \$200,000, will erect a brick and glass factory here. The company has a plant in San Francisco. The contract has been let to Rodd & Rodd, of Petaluma.

PORTERVILLE.—The Magnesite Refractories Company, recently organized with \$200,000, will erect a large magnesite reduction plant. The factory will reduce crudes for Eastern steel mills and manufacture brick and plaster. Charles E. Stetson, of San Francisco, heads the directors.

SAN FRANCISCO.—The Pacific Coast Glass Works has received a permit to build a 1-story steel factory addition to cost \$1,000.

SAN PEDRO.—Reported Union Oil Company, Union Oil Building, Los Angeles, Cal., intends erecting \$2,000,000 refining plant at San Pedro.

STOCKTON.—The Stockton glass factory will resume operations at its plant, under new ownership. The Patterson Glass Company are the new owners.

VALLEY SPRINGS.—The California Pottery Company is planning the erection of a paving brick plant at Valley Springs, in Calaveras County.

Connecticut

BRIDGEPORT.—George S. Youngs has purchased the Dwyer saw and bank on North Avenue and a large brass foundry will be located there.

District of Columbia

WASHINGTON.—Bids will be received at the Bureau of Supplies and Accounts, Navy Department, Washington D. C., for furnishing at the various navy yards and naval stations the following supplies: Portsmouth, N. H., Schedule 381, 15 four-cycle gasoline engine. Newport, R. I., Schedule 384, for furnishing and installing two out-boards for carryover saw engine and tines; Schedule 382, miscellaneous annealed seamless copper tubing; Schedule 383, 600 air pressure gauges; Schedule 390, two grinding machines; Washington, D. C., Schedule 381, one 5-hp. induction motor; Schedule 391, two grinding machines, one grinding machine (10 in. by 24 in.), one heavy milling machine, one universal milling machine, one high-power milling machine, three bench milling machines. Norfolk, Va., Schedule 388, 2280 lb. phosphor bronze wire; Schedule 387, miscellaneous brass tubing, various diameters. Indian Head, Md., Schedule 381, one iron casting, single-stage centrifugal pump. Brooklyn, N. Y., Schedule 395, miscellaneous pump parts. Applications for proposal should designate the schedule desired by number.

Florida

JACKSONVILLE.—The Southern States Paint Mfg. Co., a new organization, will erect a plant here for making a preservative paint for vessel bottoms, etc. The company is capitalized at \$25,000.

JACKSONVILLE.—Wilson & Company, successors to S. Sulzbrenner & Sons Company of Chicago, will erect a branch plant here to serve as a Florida distributing station. A refinery may also be erected in the near future. At the present time seven plants in different Southern cities are being erected by this concern, which is capitalized at \$60,000,000.

Georgia

ROME.—The old iron furnace here which has been closed for many years, has been leased by Chattanooga capitalists, and will be repaired and blown in. It is the only furnace in the section now idle.

Idaho

IDAHO FALLS.—The Western Potash Company contemplates the erection of a plant to extract potassium salts from sagebrush. Treatment of the sagebrush has been tried out in several places and promising results found. The plant will be used as a refinery and also for the burning of the brush from which the ashes are secured. A. Grimes is president, and M. A. Camp, vice-president of the company.

Iowa

CHARLES CITY.—The Hart-Parr Company has begun the erection of a steel foundry to cost \$100,000. Two 25-ton open-hearth furnaces will be installed.

Kansas

COFFEYVILLE.—The National Refining Company, an independent concern, will build a refinery here to cost \$250,000.

COFFEYVILLE.—The United Refining Company has announced that it will spend \$250,000 in remodeling its Coffeyville plant, to bring the capacity up to 250,000 barrels per month. Of independent glass, Raymond Cornish is president. There is a big demand for window glass at present.

INDEPENDENCE.—Plans are being prepared by Western States Portland Cement Company for rebuilding plant recently destroyed by fire. Cost about \$100,000.

WICHITA.—The Kanita Refining Company has begun the erection of a 500,000 refinery on the Santa Fe Railroad. The capacity will be 6000 barrels per day. E. C. Blasdel, of Pittsburgh, is superintendent.

Louisiana

BALDWIN.—The United States Sugar Company, a new organization, has purchased 1230 acres near Baldwin, and has options on 20 other plantations in Southern Louisiana. O. M. Nelson, formerly of the American Bank of New Haven, Conn., is interested in the company.

SHREVEPORT.—The National Glass Company, employing 200 men, is now operating forty-two shops, with a daily capacity of 8 carloads of window glass. Raymond Cornish is president. There is a big demand for window glass at present.

Maine

VAN BUREN.—The Aroostook Pulp Company will erect a plant to cost \$500,000 to make sulphate or Kraft pulp from the spruce waste wood from the saw mills

Messrs. E. J. Lindsey, of Boston, George Lewis, of Holyoke, Mass., and E. M. Blain, of Bath, N. H., are interested. C. A. King, of Bangor, is chief engineer.

Maryland

BALTIMORE.—The Thomson Chemical Corporation, manufacturer of sulphuric acid, has given bonuses to all its employees, ranging from 5 to 17½ per cent of their wages.

BALTIMORE.—A dinner was given to Charles M. Schwab by 300 of Baltimore's business men on Nov. 21. Mr. Schwab announced that the Bethlehem Steel Company would spend \$100,000,000 in additions at Bethlehem, Baltimore, Harrisburg and elsewhere. Between 35,000 and 50,000 men will be employed at Sparrows Point, at which place \$50,000,000 will be expended. Mr. Schwab predicted a large domestic demand after the war which would more than offset the war demand.

CUMBERLAND.—The Wellington Glass Works has begun the erection of a \$200,000 addition to its plant, which will double its capacity. Automatic glass blowing machinery will be installed. Wright, Richardson & Company, of Cumberland, have the contract for the building. The company makes lamp shades.

SPARROWS POINT.—A \$2,000,000 contract has been awarded to the Dravo Contracting Company by the Bethlehem Steel Company for extensions and improvements to the Sparrows Point plant. Four blast furnaces, a large open-hearth plant, a blooming and slabbing mill and two plate mills will be erected.

Massachusetts

GARDNER.—An effort is being made by local business men to start a paper mill here to cost \$125,000. A special committee, consisting of Chester Pease, Harold P. Drayton, Solon Wilder, Joseph P. Carney and Elmer W. Crouch, has been making investigations and raising subscriptions.

GARDNER.—Steps are being taken to incorporate the Gardner Paper Company, with a capital of \$200,000, for establishing a paper industry in Gardner. John P. O'Brien is one of the organizers.

MANSFIELD.—The Mansfield Foundry Company has secured the Ridd Foundry property and will double its former capacity.

MANSFIELD.—The New England Drawn Steel Company has decided to locate its plant on High Street on the New Haven Railroad. The company will erect several buildings.

Michigan

DETROIT.—Reported that Henry Ford will build two steel mills to supply his factories with parts. No details are at present available.

PETOSKEY.—Work has been started to repair the damage done by fire to the mill of the Petoskey Paper Company, and operations will be resumed about Dec. 1. The paper-making part of the plant will not be rebuilt, but the pulp mill will be enlarged to double its capacity.

Minnesota

INTERNATIONAL FALLS.—The Minnesota & Ontario Power Company, a new corporation affiliated with the International Lumber Company of International Falls, Minn., has awarded to the Swenson Evaporator Company, of Chicago, a contract covering equipment of machinery for a sugar refinery, pulp or kraft mill, to be erected at International Falls. This will be the largest mill of this type in America. Foundations are already in and construction is well under way. The mill is expected to be in operation by next spring or early summer.

Mississippi

HATTIESBURG.—The Hattiesburg Pulp & Paper Company has been organized to construct the paper plant here, announcement of which was given in our last issue. The company will make news print and construction will be commenced shortly. George R. Wright is at the head of the company. Charles W. Rantoul, of New York, is also interested.

Missouri

INDEPENDENCE.—The Independence Aniline Dye & Refining Company has purchased the K. I. drop force plant in Independence and will make aniline dyes, paints, enamels, patent leather, varnishes, drugs, acids, roofing paper, etc. The estimated capacity is 30 tons per day. The company is working in a small way at present, but will need retorts, stills, boilers, evaporators, mixing vats, pumps, etc. Judge Anthony J. Ford, of Kansas City, Mo., is president; Frank G. Ward is general manager; Wm. Meahl is superintendent and Prof. Paul Von Seiden-dorfer, chemist.

KANSAS CITY.—The Sinclair Oil Corporation will build a refinery here which will cover 100 acres. It was recently announced by Harry A. Sinclair, president of the Sinclair Oil Corporation, that the company has 2500 cars in service. The Sinclair company and the Cudahy Refining Company are associated in the undertaking. The Sinclair company is building an 800-mile pipeline from Oklahoma to Chicago and contemplates other large refineries to serve the Southwest.

ST. LOUIS.—The Central Iron Company will erect a modern sheet-iron plant on South 16th Street. Louis Ladoux is president.

Montana

ANACONDA.—The American Sugar Refining Company has been considering the erection of a beet sugar factory in the Deer Lodge Valley.

New Hampshire

PORTSMOUTH.—Reported that Albert L. Kraus, president of the Kraus-Millet Leather Company, has perfected a new solvent for use in the manufacture of pyroloxin products, to replace amyl acetate, which is mostly imported from Russia and Germany. The solvent is now almost ready for use. It is expected that the company will manufacture the substitute.

New Jersey

LINDEN.—Plans are reported to have been submitted to Township Building Inspector Albert Weber by a New York Company for a new dye factory.

NEWARK.—The Oxweld Acetylene Company has let contracts for three additional buildings at its plant at 646 Frelinghuysen Avenue. The buildings will cost \$14,500. Frederick Kilgus, Inc., has the general contract.

New York

BROOKLYN.—The F. W. DeVoe and C. T. Reynolds Company plan the erection of a \$100,000 paint factory at Smith, Huntington and Ninth streets.

BUFFALO.—The United States Alloys, Inc., has purchased a sixteen-acre tract adjoining a large site recently released to the Acheson Graphite Company. Both plants are near the new steam-electric plant of the Buffalo General Electric Company, between Buffalo and the Tonawandas. The new company will manufacture alloys used in steel manufacture.

DEFEW.—Albert Beebe & Company will build a \$70,000 silk mill here. The B. V. Taylor Company, of Olean, has the contract.

LONG ISLAND CITY.—The Manhattan Soap Company, of 426 West Thirty-eighth Street, Manhattan, has purchased a site on Hunter's Point Avenue, Long Island City, and plans the erection of a \$500,000 plant.

LYONS.—The Lyons Cold Storage Company plans the erection of an addition to its cold storage plant and the installation of ice-making machinery for making 30 tons of ice per day.

NEW YORK.—Werner & Pfleiderer Company, Saginaw, Mich., has taken new New York offices on the 37th floor of the Woolworth Building.

NIAGARA FALLS.—Additions are planned by the Hooker Electrochemical Company and the Carburendum Company.

PENN YAN.—Charles G. Moore, secretary of the Corrugated Container Company, of Buffalo, has purchased the Shuttar mill and will make improvements.

RENSELAER.—The Bayer Company has commenced work on another addition to its plant. Plans are being prepared for more buildings.

WATERTOWN.—The Watertown General Utilities Company, Inc., a new company, has commenced the manufacture of a cleaning compound. The present capacity is 30 barrels per day. It is expected that the plant will be doubled by spring. The officers are John W. Hyde, president; Fred Chickering, treasurer, and Sidney K. Chickering, secretary.

WATERTOWN.—The Sawyer Products Company, of East Cambridge, has purchased the plant formerly occupied by the Hemis Rubber Company, in Watertown. Extensive improvements will be made and a new line of manufacture taken up.

Ohio

CINCINNATI.—Application has been made by the Charles Boldt Glass Company for a permit to build a \$50,000 plant at 1201 Bank and Eastern Avenues.

CLEVELAND.—The Adams-Bagnall Electric Company, a new organization, has added to its factory with the installation of a complete vitreous or porcelain enameling plant. The company manufactures porcelain enameled reflectors for industrial lighting and will now have a completely equipped

plant for all the phases of manufacture. The enameling plant is being equipped for all classes of high-grade vitreous enameling. A battery of four 12-ft. furnaces will be supplemented with complete equipment of mixing vats, smelt furnaces, drying ovens and handling apparatus capable of producing a large output. The operation is in charge of men with thorough experience in vitreous porcelain enameling. The equipment is high grade of the latest design to secure uniform results. As the complete outfit is new it has been possible to make a practical layout that permits most ready handling of the enamel and material. In addition to enameling all ablates and associate equipment, the Adams-Bagnall plant will be capable of handling a considerable output of other vitreous enameling work. The plant will be in full operation before Jan. 1, 1917.

CLEVELAND.—The Artificial Silk Mills, a \$5,000,000 corporation, is building a plant at east Ninety-eighth Street and Big Four Railroad to manufacture artificial silk by a process brought over from Europe.

DOVER.—The Cleveland Steel Valve Company, capitalized at \$80,000, will erect a plant here.

MARIETTA.—The Pioneer Window Glass Company, a new corporation with \$80,000, has completed arrangements for the construction of a new glass plant in Westview.

MOUNT GILEAD.—To meet increasing business extensive plant and equipment improvements will be made by the Hydraulic Press Mfg. Company, Mount Gilead, Ohio. The improvements consist of one new building and extension to the machine shop, power house, stock room, tool room and erecting shop buildings. To relieve the crowded condition of the machine shop, an addition 20 ft. long by 60 ft. wide will be erected. Considerable new machine shop equipment will be needed for this addition, including a 20-ton electric traveling crane, a 10-hp. motor-driven horizontal boring mill and a heavy duty motor-driven planer. A 20-ft. extension will be added to the present power plant building. New boiler plant equipment will be installed, consisting of a 20-hp. Corliss engine and a 225-kw. generator. Two new steam boilers and stokers for three boilers will be added to the present boiler equipment in the power house. A building for oil storage will be erected adjoining the new power plant building into which will be installed modern oil tanks with pumps as well as steam heating pumps, oil pumps, etc. The main stock room will be extended and another story added. This will give additional space for the storage of small parts and accessories such as hydraulic valves, fittings, packings, repair parts, etc. The tool room will also be extended to provide for new equipment and more storage space for tool and fixtures, etc. A new structural shop, about 50 ft. by 60 ft. will be erected. A new high-speed cut-off saw and traveling crane will be installed in this building. Space will also be provided for the installation of two new men's sanitary closets with laboratory equipment. Individual lockers for the employees will be provided. The plans also include an extension of the machine shop building, measuring 47 ft. by 130 ft. For all of the building extensions brick and concrete construction with steel for the substructure work will be used. All of the above improvements except the last named will be made immediately.

SHARON.—The American Steel Foundries Company is erecting a large addition to its molding department. The plant is enjoying a period of great prosperity.

YOUNGSTOWN.—The Brier Hill Steel Company, upon completion of its 55 by-product coke ovens, will appropriate \$1,000,000 for 58 more coke ovens.

YOUNGSTOWN.—The construction of two new open hearths at the Brier Hill works is progressing rapidly and it is expected to have both smelters in operation by Jan. 1. The new furnaces are completed in operation, producing about 60,000 tons of steel per month.

YOUNGSTOWN.—A large company capitalized at \$1,000,000, has secured an option on a site located on the Concrete Street and Stone Company, Jones & Britain Streets. It is the intention to erect a plant for manufacturing acetylene and oxygen for welding purposes.

YOUNGSTOWN.—The Trumbull Steel Company has awarded contracts to the Wellman Sauer Morgan Company, of Cleveland, for four Hughes soaking pits and to the Allene Machine Company, of Alliance, Ohio.

YOUNGSTOWN.—Structural steel has been purchased by the Youngstown Sheet & Tube Company for an extension to the department plant in the open hearth department. Figures that millions would be

spent on extensions in the near future have been heard.

YOUNGSTOWN.—Youngstown Sheet & Tube Company, Standard Building, contemplates improving plant extensively.

Oregon

KLAMATH FALLS.—A beet sugar factory will be established here if present tests on beet culture are successful.

PORTLAND.—The Northwest Steel Company is erecting a rolling mill in connection with its shipbuilding plant in South Portland.

Pennsylvania

ALLENTOWN.—The Allen Chemical Company is erecting a phenol plant 40 by 130 ft. near Fifth Street, in Avenon.

CARNEGIE.—The Union Electric Steel Company of Pittsburgh, a \$350,000 corporation, has acquired a site of three acres in Carnegie on which to erect an electric steel plant. The Harold R. Kohn, Jr., president, James D. O'Neil, formerly president of the United Coal Company, is president of the new company; H. O. Murphy is secretary-treasurer and W. J. Walker is superintendent.

DONORA.—The Fuller Engineering Company, of Allentown, Pa., are furnishing a complete pulverized coal plant and furnace for slig for eight to ten open-hearth furnaces for the American Steel & Wire Company.

FARRELL.—The American Sheet & Tinplate Company will erect ten additional hot plate mills at a cost of \$1,000,000.

FRANKLIN.—The Celanese Signal Oil Company plans the erection of a \$100,000 refinery to produce motor oil.

HARRISBURG.—The Harrisburg Chemical & Paint Company will enlarge its plant on Hemlock Street. Application has been made to increase the capital from \$15,000 to \$100,000. William R. Reine, president. Among the products of the company is a rust-proofing oil.

NEW CASTLE.—The American Sheet & Tinplate Company has appropriated \$1,000,000 for 40 new hot plate mills at its Shenango works, in addition to the appropriation for the Farrell works. The Shenango works is the largest of its kind in the world.

PHILADELPHIA.—S. B. & W. W. Fleisher will erect a six-story textile mill, together with a special bleachhouse and dyehouse. Both tub and machine dyeing will be done.

PHILADELPHIA.—The Belmont Packing & Rubber Company plans the erection of a plant in Philadelphia. The offices of the company are at 139 North Second Street, Philadelphia.

PITTSBURGH.—The Carnegie Steel Company plans the construction of a sintering plant near Pittsburgh for the sintering of fluo dust under a process just acquired.

REYNOLDSVILLE.—The Elk Tanning Company has received large leather orders from Russia and far eastern markets, and will make extensive additions to its plant in order to fill them. More than 6600 ft. of floor space will be added.

STRUTHERS.—The American Sintering Company is erecting a sintering plant near here to sinter fluo dust from the Youngstown Sheet & Tube Company, Republic Iron & Steel Company, Struthers furnace and the Mary stack at Lovellville.

Tennessee

CHATTANOOGA.—Wilson & Company, the successors to S. Sulzberger & Sons Company, the Chicago meat packers, will begin operations Dec. 1 at its new plant, one of the largest in Chattanooga. Over \$500,000 has been expended. The new plant will be manufactured to supply all of Wilson & Company's distributing houses in the Southeast. Cottonseed oil will be refined.

Texas

BEAUMONT.—The Texas Steel Company, recently incorporated with \$2,500,000 capital, is erecting a plant which will have a daily capacity of 100 tons. The ore comes from East Texas and is a high-grade hematite, suitable for the modern open-hearth process. Beaumont is conveniently situated, steel being obtained by water from Alabama and limestone from Austin. The Alabama ores are lower grade and require more flux than these Texas ores.

HOUSTON.—The Stauffer Chemical Company of New York and San Francisco, will erect a large chemical and fertilizer manufacturing plant on the ship channel. A site had been secured adjoining the Magnolia Petroleum Company's plant at Morehead, now under construction. The Texas Portland Cement Company has a big plant in this section, operating 24 hours per day.

Utah

OGDEN.—The People's Sugar Company is building a plant at Maroni, Summit County, in the midst of a tract of 20,000 acres suited for beet culture. George E. Downing, of Ogden, is head of the company.

MARYSVILLE.—Several buildings of the Mineral Products Corporation were partially destroyed by fire early in November. The coal house, compressor house, blacksmith shop, snow shed, straw house, etc., were burned, entailing a loss of \$75,000. These will be rebuilt as soon as possible. The plant is operated by Armour & Company, and is valued at \$300,000.

PARK CITY.—The Broadwater Company will remodel its mill and install additional machinery and will then begin working a big acreage of tailings. Mr. W. H. Kurylan has charge of the sampling of the company's holdings.

The new electrolytic plant of the Judge Mining & Smelting Company is progressing nicely. From present indications the plant will be in operation in the new year. Kurylan is general manager and Eric Neilson is construction superintendent.

SALT LAKE CITY.—The Utah Copper Company contemplates spending \$5,000,000 in enlarging its mills at Magna and Arthurs, and at Garfield. This does not include the million dollar appropriation for enlarging the tailings pond.

The American Smelting & Refining Company will spend \$5,000,000 in enlarging and improving the Murray and Garfield plants, including new zinc smelting equipment.

Virginia

CHARLOTTESVILLE.—H. E. Young & Company will build a \$150,000 plant for manufacturing dye and extracts.

NORFOLK.—Fires destroyed several large buildings here on Saturday, Nov. 1, causing a loss of \$400,000. The Twin City Iron Works and the Norfolk Hide & Metal Company will erect new buildings to replace the destroyed ones. The Hide & Metal Company has secured temporary quarters pending the repair of another building owned by the company. The company had \$40,000 worth of hides, the damage to which is unestimated.

RICHMOND.—The American Locomotive Works is negotiating for property west of its Richmond branch, on which it is proposed to build an iron foundry.

RICHMOND.—The Dixie Paper & Pulp Company is negotiating for a site on which to erect a plant. The company was recently incorporated for \$50,000. Richard H. Smith, of the Planters' National Bank, is interested.

Washington

SPOKANE.—The Slocan Star Mines, Ltd., operate its mill with a new hydro-electric power plant recently completed. The company produces zinc concentrates.

SPOKANE.—The United Gold Mining Company will shortly begin milling operations at the Cougar property. Cyanide, lime and boxes of machinery recently reached the property from San Francisco. Algernon Del Mar is metallurgist and mill superintendent, and W. W. Robbins of Spokane is mine superintendent.

TACOMA.—Improvements are being made to the Tacoma smelter of the American Smelting & Refining Company, including the construction of a large fluo from the furnaces to the concrete stack. Further enlargements to this plant are expected, and it is reported that a steamship line will be established to South America to bring copper ore here for smelting.

West Virginia

CLARKSBURG.—Glass factories are suffering from a shortage of freight cars for hauling sand. Officials of the Baltimore & Ohio Railroad have promised relief.

Wisconsin

MILWAUKEE.—The Wash-Rite Glove Company will erect a tanning plant to cost \$28,000, at North Pierce and Center Streets.

Canada

COCHRANE, ONT.—The Frederickhouse & Asholt Pulp Wood Company plans the erection of a new plant to cost \$150,000. J. A. McAndrews, Lumsden Building, Toronto, is in charge.

Hayti

PORT AU PRINCE.—The Haytian-American Corporation, controlled by American capital, plans to build the largest sugar refineries in the world in Hayti. A. J. Grief, formerly associated with the late E. H. Harriman, is president.

Metallurgical and Chemical Engineering

A Consolidation of
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Supreme Court Decision in Hyde Flotation Suit

The Supreme Court of the United States on Dec. 11 rendered the final decision in the suit of Minerals Separation versus James M. Hyde, reversing the Court of Appeals of the Ninth District at San Francisco and affirming the decision of the lower court at Butte, Mont., in favor of Minerals Separation. A record of the principal stages of this suit may be found in our Vol. XII, page 362, and Vol. XV, page 555. Since at the time of going to press the full text of the decision (which is stated to have been written by Judge Clarke and to have been unanimous) has not yet come to our hands, we must reserve further comment for our next issue. It is evident, however, that the Supreme Court has upheld the validity of the claims of patent 835,120 (owned by Minerals Separation) for less than 1 per cent of oil. And this is the fundamental point.

The Miami appeal to the U. S. Superior Court in Philadelphia from the Wilmington decision of Judge Bradford (our Vol. XIII, page 409, and Vol. XV, pages 433 and 441), is expected to be heard on Jan. 30, 1917. The flotation suits are, therefore, by no means at an end yet.

Passing the Buck

As was anticipated by students of the psychology of the Secretary of War, the temporary permit to generate more power at Niagara Falls was refused. To the representations of the Board of Directors of the American Electrochemical Society the Secretary of War replied by referring to a memorandum which appears in another column. The lengthy argument in favor of dodging the issue is apparently re-enforced in Mr. Baker's mind by a consideration that "the Falls themselves are one of the greatest, if not the greatest, natural wonders in the United States." Hence Mr. Baker argues that "under such doubtful powers" as he possesses he has not the power finally to set at rest the question of diversion. Evidently Mr. Baker thinks that a temporary permit to use about 1.5 per cent of "this mighty spectacle" would settle the question for ever.

It would be interesting to know why Mr. Baker's doubtful power was used to grant a temporary permit to use more water with the provision that the power generated from it should not be used in Niagara Falls.

Meanwhile the future is gloomy, for it is almost too much to expect Congress to settle the question in the very short session before it. If, however, it could find time to prop up the feeble arms of our doubting Secretary, so that the temporary permit could be granted, it would deserve the gratitude of the whole country.

Prices Up in the Air

We printed in our last issue a timely paper by G. O. Smith and C. E. Leshner of the U. S. Geological Survey on the cost of coal. It goes without saying that we have been doing very loose figuring in regard to this great source of wealth. We have been addicted to the glib but unconvincing theory that civilization may be measured by the quantity of coal destroyed, and we have been given to shallow rejoicing because the consumption in the United States for heating and lighting is as great as it is. By this statistical art we charge every papoose of the plains and sierras, and every picanninny of the alligator districts with 1 1/10 tons of coal, and by the same token we know that the rest of us use more. It does beat all, the kind of things we can really grow proud over, once we begin to expand our chests! We have not computed the average number of calories needed per person and compared this with the average B.t.u. available from 1 1/10 tons of coal in order to justify our boast of a red hot civilization that burns up so much. In certain of the countries now at war it is forbidden to burn coal for domestic use on the ground that the by-products which would thus be destroyed are needed for munitions. Householders must use coke; then the by-products are saved.

In the arts of peace these by-products are equally useful, and many things that are nowadays found useful in time of war will surely prove themselves worthy the attention of citizens in times of peace. Indeed, it is a fair guess that many varieties of profligate waste now practiced in this country will soon have the ill-repute they deserve.

In considering the costs of coal, Dr. Smith has brought out a factor which we have not considered heretofore as nearly so important as the facts seem to warrant. He calls this the "Resource Cost," and it has to do with the royalties paid to the lord, the patron or the owner of the land. This charge, he finds, runs up as high as \$1 per ton of anthracite, taken from certain mines. The available anthracite being limited, the price of such coal lands has risen from \$3 to \$4 per acre to \$3,000 of late years. The Girard College Trust gets, under its latest contract, about \$1 per ton royalty on anthracite coal mined from certain lands which it owns. So long as anthracite is a necessity, and there is no more in sight, there does not seem to be any top to the royalties that may be enjoyed by the fortunate possessors of these lands.

This leads us into all sorts of economic difficulties. Let us suppose that we were The People of the State of Pennsylvania, and were called upon to solve the problem. Without doubt, the anthracite railways would assure us that if the right of eminent domain were given to them over all anthracite coal lands they would meet the situation with justice and efficiency. Somebody else might propose the Henry George Single Tax law, with a view to bringing the unused lands into the control of the State. Dr. Smith feels that the public control of coal lands is the solution of the problem. All of these proposals, except the most drastic one of Henry

George and Herbert Spencer, involve taking from the owners of the coal lands the liberty to trade.

Now let us propose an economic theory right off the bat, and invite discussion. We postulate that all these palliative measures, such as State or federal control, etc., become necessary only when the public is not good enough or wise enough to meet simple situations. The selling public is not good enough if it imposes selling prices so high above costs as to cause an injury to the public, and the buying public is stupid if it pays the price. Most of us combine these two functions of selling our work and buying for our needs, so we are, nearly all of us, in the same boat.

Stupidity consists in large measure in the inability to shift from one angle of vision to another. If anthracite coal is too high and coke is cheaper, it is stupid not to use coke. If we are intelligent enough and have ginger enough we can make the shift; if we are not intelligent enough we cannot. It will be too difficult, too much trouble and, somehow, we shan't manage to get around to it. The man that has no time to take trouble has not the capacity to make anything but trouble.

It looks as though we had lost our kick and had become easy marks through sheer inertia. A woman went out to buy a pair of shoes, and learned that, owing to the scarcity of leather, the price of shoes had advanced \$2 a pair. With a view to economy, she asked for cloth shoes and was informed that the price of these was the same as those of leather. She then asked for low cloth shoes, and discovered that high or low, big or little, cloth or leather, the price of shoes was the same. What can be the matter with the customers of that store that the shoe-wallah can put over a game like that?

Little strips of sheet celluloid sold by apothecaries for tongue scrapers can hardly cost a cent. They retail for 10 cents each. In certain units of a chain of drug stores that display marvelous bargains in their show windows the price is 50 cents. "Celluloid is very expensive now," said the poor clerk. Poor man's coal in October was 25 cents a "basket," and in November the same amount costs 35 cents. The only explanation of that extra 10 cents is that the public will swallow any story as a reason for advancing prices. Apples are rotting on the ground in many places, but "everything is going up," and so the cost of apples to the consumer is soaring. Butter, eggs, and provisions are almost unprecedented in prices owing to the great scarcity, and yet the cold storage warehouses are stuffed to repletion with reserve supplies such as they have never carried before.

Now what are prices? They are what the owner of wares can get for them in exchange—what he can get purchasers to pay. If the purchaser is puny and weak, and has no resistance and lacks the strength to kick when too much is asked, and does not know when he is being overcharged, he will be asked too much every time. And he will have to pay. It looks as though the whole American public had lost the art of

buying, and if we have, all the socialistic laws that ever were thought of will not help us. We shall be anybody's meat.

The Steel Trade's Future

Is the steel trade facing an economic crisis? There has been a disposition in the present calendar year to cast such fears aside, because early this year a famous precedent was set aside. The trade had previously adhered to an idea that certain prices were "safe" and that the establishment of higher prices would lead somewhat quickly to a reaction, through consumption being curtailed. The highest steel prices between 1902 and 1916 were reached in 1907. A weighted average of finished steel prices, carefully kept for years, shows that at the end of 1915 the 1907 level had just been reached. Early this year steel prices transgressed that limit and yet buying was not curtailed. The steel companies have a much larger amount of business on books now than they had at the beginning of the year, and some of them suggest that they wish they had less.

The fact that the honored price limit has been exceeded without anything happening is no proof that conditions are safe. It is proof of nothing except that nothing has happened thus far. The advance in prices thus far this year is equal to double the advance that occurred last year. In other words prices have advanced, since the low point of December, 1914, three times as much as was required to bring them even with the top prices of 1907.

To cite the fact that steel prices have lately been advancing more rapidly than ever is, of course, no argument that there is no danger, but rather the contrary. According to the weighted average mentioned, the advances in the month of November were more than one-fourth the total advances that occurred in the preceding ten months. The curve of ascending prices is convex to the base line, suggesting that the line is soon to reach the impossible, when something must break.

Can the steel market yield merely to the extent of experiencing a period of stationary prices? Precedent is against such an assumption. In 1905 and 1906 steel prices rose, and remained stationary, through their own inherent strength, through the first ten months of 1907. They did not really break until more than a year later, but the support was artificial, with a great curtailment in production. That was the "Gary dinner" period, well remembered. In 1909 prices rose sharply, but they remained stationary at the top only for a few months, and the same statement can be made of the 1912 rise. Even in this present movement, the greatest of all, there has been something suggestive. There was a particularly rapid rise in prices during the first three months of this year, after which prices became relatively stationary, and quite promptly there arose fears that a break would occur before the end of the year. Possibly it was only because prices commenced a

fresh and important advance last August that fears have been dismissed.

Now if the steel market feels safe as to its future only when prices are in the course of advancing it is really in a very unsafe position, for it is when prices are advancing that the position is being made less secure for the more distant future. Whatever goes up must come down, and the downward pull upon prices is not like the force of gravity, decreasing as the square of the distance, but more like the tension of a spring, increasing as it is distended.

Of the steel produced in the United States since the beginning of the war not more than 25 per cent has been exported, directly or indirectly. A continuance of the present demand requires therefore a continuance of the buying in the same proportions as hitherto, or, if buying in the one quarter is decreased buying in the other quarter must be increased correspondingly, and there must be at least a slight increase in the total to take care of the gradually increasing productive capacity. In the domestic market the ultimate buyer may be divided chiefly into two classes, the investor, who erects a bridge, an office building, a factory, or something of that sort, and the common people, who buy tin cans with food, paint, etc., inside, magazines with wire stitching, tools, stoves, and indeed a very wide range of things. Now the investment buyer is, on the whole, far from active. Reports of the Bridge Builders' and Structural Society show that in August, September and October the structural steel lettings were less than 65 per cent of the fabricating capacity. As to the common people, the high cost of living is forcing them to economize, whereby they buy less quantity than formerly even though they spend more money. With the steel industry it is purely a question of quantity. It is the tonnage that must be sold.

There is a theory prevalent just now that if the American people find themselves unable to continue in future to buy three-fourths of the steel we produce the foreigners will buy whatever is left for them. Assuming that the proportions have been 75 per cent and 25 per cent, then if domestic buying is reduced one-third export buying must be doubled, to maintain the total 100 per cent, disregarding the fact that productive capacity is increasing. For exports to double would be a sensational development. Our merchandise export trade in general is enormous only as to its value, not as to its quantity. The world's merchant shipping is less than before the war started, and the quantity of goods exported cannot be much if any greater than formerly. The tonnage of steel exported is, however, about double the quantity exported in 1912 or 1913, so that it is already large in quantity as well as in value. It is true that at the present time export prices for steel are higher than domestic prices, but it does not follow that the foreigners would continue to bid the higher prices if they were offered a materially increased quantity of steel.

Readers' Views and Comments

Guayule Rubber and Canaigre Tannin

To the Editor of Metallurgical & Chemical Engineering

SIR:—The article on the guayule rubber industry in your issue of Nov. 15 and the editorial on the same were interesting and timely.

I happened to be upon a professional visit at Mapimi, Mexico, at the time guayule was being gathered in that vicinity. During the first two weeks of my visit the Penoles company's railroad was crowded to capacity in handling the shipments. But soon the territory tributary to this road was completely exhausted.

The result of attempts to grow the guayule plant and finding a lack of gum in the cultivated plant is paralleled by the experience previously found in attempts to grow canaigre root for tannic acid. The natural desert growth contained a high percentage of tannin. But while the plant grew luxuriantly under irrigation cultivation, the cultivated plant contained so little tannin as to be practically worthless.

Unfortunately a tannin works with large copper stills was built near Denning, N. M., while the cultivated crop was being grown. The works stood idle for many years and were finally dismantled.

R. C. CANBY.

W. Hartford, Conn.

Screen Efficiency

To the Editor of Metallurgical & Chemical Engineering

SIR:—On page 320 of the issue of METALLURGICAL & CHEMICAL ENGINEERING for Sept. 15, 1916, the following method of calculating the efficiency of a screen is given:

Efficiency =

Weight of undersize passing through screen

Total weight of undersize in feed to screen.

For some years I have made use of the familiar formula for calculating extractions in connection with mill work, which involves only assays or percentages, no weights being necessary.

$$E = \frac{c(a-b)}{a(c-b)}$$

where

a = assay of heads.

b = assay of tails.

c = assay of concentrate.

E = extraction, as a decimal.

In order to illustrate the application of this formula to screens, the following screen analyses are given:

CUMULATIVE PERCENTAGES ON THE VARIOUS SIZES

Mesh	Feed	Undersize	Oversize
20	14.8%	1.2	55.9
30	28.8	12.7	81.0
40	39.4	24.4	87.8
60	62.8	49.3	92.4
200	83.4	73.9	95.6
280	100.0	100.0	100.0

These are the results of screen analyses of the feed, undersize and oversize, where the material was fed to a 30-mesh screen.

Where fine screening is being done, it is important to know the efficiency of the screen on the small sizes. If much of the fine material goes into the oversize, it would indicate that the screen was being overloaded, or else an insufficient quantity of wash water was being used.

Assume that it is desired to calculate the efficiency of the 30-mesh screen on 80-mesh material. Then

a = per cent through 80-mesh in feed.

b = per cent through 80-mesh in oversize.

c = per cent through 80-mesh in undersize.

Subtracting the cumulative percentages on 80-mesh from 100 to get the percentages through 80-mesh and substituting in the formula:

$$E = \frac{50.7(37.2 - 7.6)}{37.2(50.7 - 7.6)} = .936 = 93.6 \text{ per cent efficiency.}$$

In the example given in the article referred to, the data was for a 1.5-mm. screen.

Size	Feed	Oversize
Over 1.5 mm.	80.1%	87.5%
Under 1.5 mm.	19.9	12.5
	100.0	100.0

The percentages through 1.5 mm. for the feed and oversize are 19.9 and 12.5 respectively. In order to apply the formula the percentage of undersize through 1.5 mm. must be known. As no figures are given for the undersize, it is assumed that this figure is 100 per cent.

$$\text{Then } E = \frac{100(19.9 - 12.5)}{19.9(100 - 12.5)} = 0.427 = 42.7 \text{ per cent}$$

as against 42.51 per cent by the first method.

The discrepancy of 0.2 per cent might be due to some of the oversize going into the undersize. Elongated particles might pass the screen during a test and yet be caught on the same size opening when the screen analyses were made. In any case, the checking by the two methods is far closer than the inaccuracies of screen testing would lead one to expect.

ROBERT S. LEWIS,

Associate Professor of Mining.

University of Utah,
Salt Lake City, Utah.

Some Evidence Regarding Oxidation of Metals in Heating Furnaces

To the Editor of Metallurgical & Chemical Engineering

SIR:—An analysis of the flue gases emerging from a billet-heating furnace when fired with fuel oil as compared to the analysis of the gases from the same furnace in firing with powdered coal affords interesting data on which to base a theory in regard to the destruction of metal by oxidation within the furnace. In a number of instances wherein I have made a series of gas analyses in both cases I have found that with fuel oil, when operating under what were considered by the heater to be good furnace conditions, the flue gases analyzed from 8 to 11 per cent of CO.

Under these conditions the scaling of the billets was very noticeable, there being approximately five sixty-fourths of an inch of scale, this being the average of a number of measurements taken from various parts of the bar. When the bar is pulled out of the furnace door and allowed to drop onto the floor plates a very noticeable deposit of scale is produced. It falls off of the bar in large flakes or scales, which are of sufficient thickness and strength to maintain their form and permit of free handling in pieces up to 5 and 6 in. long. The scale in this instance is shiny and smooth on the outside and has a pitted, rough interior. A cross-section shows the structure quite clearly, the external half being very dense and compact, and showing that the oxide is solid and continuous. The interior half of the scale is inclined to be spongy and porous, and on the surface has a deeply pitted aspect.

This being a method of firing which has been in service for some years, statistics are available in regard to the actual percentage of scale loss. This runs according to the character of the steel and the amount of original rust, from 4 to 6 per cent by weight.

Observe now the scale produced from exactly the same billets in exactly the same furnace, but fired with pulverized coal as a fuel. The change from oil to coal was accomplished over night, and the same crew was in charge of the operations, and the billets came from the same pile in the yard. I feel, therefore, that there was no change in the conditions other than the fuel, so that any effect on the scale could be directly attributed to this. Perhaps the fact that the billets heated more rapidly had something to do with it, but it was quite noticeable that the amount of scale dropping off the billet when it hit the floor was less in the case of powdered coal than with fuel oil. Analyses of the flue gas with coal showed a practically constant quantity, there being between 15 and 16 per cent of CO_2 . Inasmuch as Indiana coal was being used, the sum of the CO and oxygen was about 19 per cent. The average amount of free oxygen in the flue gases was therefore between 3 and 4 per cent.

This particular furnace has not been operated as yet a sufficient length of time to get a line on the percentage of scale loss. This is a figure which it is difficult to get accurately except by using the figures derived from several months' operation.

It was difficult to get a piece of scale from the coal-fired furnace large enough to use as a sample, because it was so thin that it was exceedingly fragile. The lessened amount of scale was, however, so noticeable as to be commented upon by the mill men. Further and more accurate data will be developed before very long, in connection with a continuous rail-heating furnace which I am now equipping with powdered coal.

The value of this evidence can scarcely be overestimated, there being more economy derivable from this than from the fuel saving itself. The normal capacity of such a furnace as I have in mind is about 200,000 lb. per day. Assuming that there is a scale reduction of 2 per cent, there would follow a direct increase in the amount of steel produced of two tons per day. Assuming again that the differential between scale and steel is \$40 per ton, there will follow a daily saving of \$80 or an annual saving of \$24,000.

Inasmuch as the entire equipment for producing and supplying pulverized coal to such a furnace is well within this figure a saving of considerable magnitude is apparent. In theory, at least, the oxidation of steel should be in proportion to the amount of oxygen present in the furnace. I am hoping that my contention will be borne out in practice that metals can be heated up to at least 2000 deg. in a neutral furnace without any oxidation whatsoever. This is accomplished in such cases as sheet and pair furnaces with hand-firing, but is only done at a considerable cost in efficiency loss due to the method of firing. I have hopes that the day is coming when steel can be heated to a rolling temperature without any loss whatsoever from oxidation.

Chicago, Ill.

JOSEPH HARRINGTON.

Belgian Kiddies, Ltd.

An informal committee of American Mining Engineers is sending out an appeal to mining engineers throughout the United States, reading in part as follows:

"An informal committee of Mining Engineers, from all over the United States, are undertaking to give our friend Herbert C. Hoover a Christmas present, by tak-

ing off his shoulders part of the burden which he and his associates have been carrying for the last two years and a half.

"During this time, the United States has received a great deal of gratitude from Belgian people which it has not deserved. To the Commission for Relief in Belgium all praise is due for its work. The C. R. B.—as it is known—has distributed in Belgium goods costing about \$227,000,000, of which the United States has contributed \$10,000,000 or about 4.3 per cent of the total; and much of this has come from a few large foundations.

"This is naturally discouraging to us who know and appreciate the work of American Engineers in Belgium. These men have been keeping alive a population of nine million on one meal a day. This is not enough for children. (Would you like it for yours?) At present one million children are failing in health, and the C. R. B. has asked us Americans to assume the proper feeding of these children as our little share of the big job.

"To do this right the C. R. B. has started to give the children a nourishing noon-day meal, and it has not the money to carry it on. This costs only \$1 per month per child (three cents a day). This seems incredible but as the overhead expenses of the C. R. B. are only $\frac{1}{4}$ of 1 per cent of the gross cost you will understand that this is real engineering efficiency.

"As Engineers we want to show our appreciation and so we have organized an informal syndicate to float a new venture. We would like to cable Hoover before Christmas that we will take a block of 'Belgian Kiddies' off his hands."

The program is to float 10,000 shares of a demand value of \$12 each. "Each share sold means 365 square meals for one child."

The appeal is signed by W. H. Bassett, F. Bradshaw, D. W. Brunton, D. H. Browne, R. B. Carnahan, Jr., R. M. Catlin, A. C. Clark, J. P. Channing, F. H. Clymer, J. V. N. Dorr, W. Douglas, H. S. Drinker, T. C. Dupont, S. A. Easton, C. W. Goodale, J. C. Greenway, H. G. Hixon, C. B. Hollis, R. J. Holden, R. W. Hunt, G. P. Hulst, H. Jennings, D. C. Jackling, W. R. Ingalls, W. Kelly, E. B. Kirby, C. B. Lakenan, D. A. Lyon, J. F. McCarthy, C. H. MacDowell, G. Macfarlane, J. MacNaughton, E. P. Mathewson, C. G. Memminger, C. W. Merrill, C. E. Mills, P. N. Moore, S. W. Mudd, R. V. Norris, H. C. Parmelee, C. F. Rand, F. B. Richards, R. H. Richards, L. D. Ricketts, M. Roberts, J. C. Ralston, D. M. Riordan, T. Robins, T. A. Rickard, W. L. Saunders, E. A. C. Smith, F. M. Smith, J. M. Sully, T. B. Stearns, C. R. Van Hise, W. R. Webster, H. V. Winchell, C. W. Whitley, I. C. White, P. Yeatman.

Subscriptions are to be addressed to Belgian Kiddies, Ltd., Room 2124, 120 Broadway, New York City. It is hoped that the entire sum will be subscribed for before Christmas.

The Niagara Power Crisis

The final outcome of the power crisis at Niagara Falls is now in the hands of Congress, the Secretary of War having skilfully side-stepped the issue. His reply to the letter addressed to him by the order of the Board of Directors of the American Electrochemical Society and reported in our issue of Dec. 1 (page 617) consisted of a reference to the following memorandum:

War Department,
Washington.

Oct. 31, 1916.

Memorandum decision of the Secretary of War:

I have before me certain papers with regard to a proposed additional diversion of water from the Niagara River. These papers comprise an elaborate report to the Chief of Engineers, through the division engineer of the Lakes Divi-

sion, setting forth in detail the present power development and use on both sides of the Niagara River, and lead to a recommendation that a temporary permit be granted to the Niagara Falls Power Company for a total diversion of 10,000 cubic feet per second, with a proviso that the additional power developed be sold to the Buffalo General Electric Company, and that a temporary permit be granted to the Hydraulic Power Company for a total diversion of 8785 cubic feet per second, with certain limitations upon the use and distribution of the additional power generated, that these permits may be limited in time and be subject to cancellation at any time by the Secretary of War. The Chief of Engineers has carefully examined these recommendations, and in the main concurs in them, so that the question before me is upon the issuance of such temporary permits.

At the outset I should express my approval of the thoroughness with which this investigation has been made and the wise and adequate safeguards recommended by the Chief of Engineers upon the action proposed to be taken.

But the question presented is one of very great importance and one having a history, and I must determine, first, whether I have any legal authority to issue the permits proposed, and, second, if I had such authority, whether it is sound administrative policy for me so to do.

The diversion of water at Niagara Falls for the generation of power began in 1892, at which time there was no international agreement between Canada and the United States on that subject and no legislation of Congress attempting to regulate such diversion. Since that time various legislative enactments and one treaty affecting the subject have been enacted. Chronologically considered, the legislative enactments are the two general dam acts and the so-called Burton Act. The treaty is, of course, the International Agreement between Canada and the United States fixing a limit of 20,000 cubic feet seconds as the total amount of water which may be diverted on the American side. The policy of Congress as at present expressed denies to the Secretary of War the right to authorize the diversion of water from international boundary streams until after Congress shall have first in individual and particular cases so determined. The provision of the present General Dam Law (Act of 1906, amended by the Act of 1910) in terms deal with streams in which water is to be accumulated by the construction of dams prior to its diversion. To this extent, therefore, the Act is not applicable to the Niagara River, since no dam has been, or needs to be, constructed there. It might be possible to assume either that the Congress regarded the difference in water level at Niagara as a natural dam, or that the General Dam Law wholly omitted Niagara Falls and intended to leave that stream the subject of special legislation because of the obvious special features affecting its treatment. The latter view seems the more reasonable, in view of the fact that the so-called Burton Act passed in 1906 did deal expressly with the situation at Niagara Falls. This Act limited the amount of water which could be diverted under permits issued by the War Department to 15,600 cubic feet seconds. At the time of its passage, the Burton Act was regarded as a temporary expedient recognizing the existence of certain occupants of this water power by limiting the total diversion, and the Act was itself limited to expire by its own terms. Congress from time to time reconsidered the subject and extended the date of expiration of the Burton Act, but at no time authorized a diversion in excess of that contained in the original law. On March 4, 1913, the Burton Act as extended expired by limitation, leaving no law in force either giving authority to the War Department or in any other way affecting the diversion of water at this point. In the meantime, shortly after the passage of the original Burton Act, the International Agreement was made, by which the United States was authorized to sanction diversions up to the amount of 20,000 cubic feet seconds, but this treaty gives the War Department no power, and Congress has not legislated under the treaty to give to the Secretary of War or to any other Governmental agency the right to regulate these diversions within the treaty allowance. If, therefore, the Secretary of War has any legal authority in this matter, it must proceed from the provisions of the General Dam Act, and that by an uncertain, if not a strange, construction.

It might be said that the Secretary of War, acting with the Chief of Engineers, has power, under Section 10 of the Act of March 3, 1899, but in view of the fact that the legislation of Congress with regard to the diversion of water for power purposes has always been, or has in recent years been, entirely separated from its treatment of the diversion of water for the purpose of changing the course of streams, this suggestion lends but doubtful assistance in the effort to seek departmental authority for the proposed permits. The net effect, therefore, is that the authority of the Department in the premises is doubtful.

For many years pressure has been brought to bear both

upon Congress and this Department for permission to increase the diversion of water at Niagara Falls. Great commercial and industrial interests have developed at the site of this spectacular water power. The falls themselves are one of the greatest, if not the greatest, natural wonders in the United States; the power there is concededly the greatest water power in our country. There has been a conflict of feeling in the country as to whether commercial and industrial uses should be favored or rigid regulation imposed upon them in the interest of the preservation of this mighty spectacle. It may be that this division of feeling is responsible for the Congress having failed as yet to establish finally a policy, and this Department, under such doubtful powers as are above set forth, has not the power finally to set the question at rest. The most that could be done by the Department in the issuance of temporary permits of the character proposed would be to complicate the problem of ever finally settling a policy for, if these permits should be granted, engagements would inevitably be entered into by the enterprises using this additional power, commercial and industrial expectations would be created, and when Congress came to consider the whole question, it would find itself embarrassed by the fact that this Department had allowed industrial and commercial ventures to expand and make investments and contracts, which, while giving them no lawful claim, would create equities in their behalf prejudicial to what might otherwise be deemed the general public interest in treating the question. As I have said, efforts have been constantly made in recent years to secure authority for increased diversions. The representations now made do not differ in character from those made aforesaid. The difference lies wholly in the fact that we are in a period of quite unusual industrial activity and the expansion of the industries located at Niagara Falls seems to those interested in them to be associated with the general question of the country's industrial activity and therefore to present what is termed an emergency requiring immediate relief. Congress will meet in December. It will undoubtedly have before it the whole question of the treatment of water power and many of its members have for years been acquainted with the situation at Niagara Falls. The solution of the problem presented by the diversion of water there can be brought to the attention of the legislative body whose proper function it is to consider both the private and public interests involved, and I cannot consent to take advantage of a doubtful power for the purpose of temporary relief in industrial and commercial matters, and at the same time complicate the problem which the Congress must consider and leave that body less free to solve finally this most important question. I cannot, therefore, issue the temporary permits recommended and request the Chief of Engineers to notify those interested in such permits that their relief lies with Congress and that this Department will limit its action to the execution of such laws and policies which Congress establishes on the subject.

NEWTON D. BAKER,
Secretary of War.

The Secretary of War having refused to take action himself has, according to the news from Washington, recommended that temporary permits should be given to generate more power and has also advised Congress that in considering its legislation as regards further diversion it should keep in mind the preservation of the Falls by actually diverting more water. This is recognized as very interesting, but hardly a solution of the present crisis since legislative action by Congress during the present session seems highly improbable.

Meanwhile, the Canadian Government has not yet made the threatened prohibition of export of power. There has been a meeting at Ottawa attended by representatives of the power companies and there will no doubt be some action in the matter before long.

It is believed that the Canadian Government officials are really anxious to avoid causing inconveniences and loss to the United States manufacturers, but while desiring to be perfectly just they cannot let their own people suffer for a lack of power to which they are entitled. Therefore eventually export of power to the United States from Canada will be stopped unless there is an extraordinary check to industrial activity. This is not expected, but rather that the demands of Canada for power will increase much more rapidly than our Congress can legislate.

Coming Meetings and Events

American Association for the Advancement of Science meets with American Chemical Society, American Electrochemical Society and the four engineering societies at the Engineering Societies Building, New York, Christmas week, 1916.

American Institute of Chemical Engineers, New York, Jan. 10-13, 1917.

Society of Chemical Industry, New York Section, Perkin Medal Award, New York, Jan. 19, 1917.

Refractory Materials

Symposium Before Faraday Society

The Eighteenth Ordinary Meeting of the Faraday Society was held on Wednesday, Nov. 8, 1916, at the Institution of Electrical Engineers, Victoria Embankment, London, W.C., when a general discussion was held on refractory materials.

The president, Sir Robert Hadfield, was in the chair, and he opened the proceedings with an introductory address.

In spite of the vital importance of refractories to many national industries, the subject has received little attention in this country during the last few years, and in many instances the industry had not the scientific foundation required for its healthy development. That was the justification for the present symposium, out of which it was hoped improved practice would spring. The chief sources of refractories were probably silica, chrome clay, magnesite, dolomite, chromite, bauxite, graphite, and zirconite. The president next touched on the question of the properties of refractories, and he gave an abstract of the "Standard Specifications for Refractory Materials" published by a joint committee of the Institution of Gas Engineers and the Society of British Gas Industries in 1912. In 1908 Mr. F. J. Bywater had read an important paper on this subject before the former institution, and this was being reprinted in connection with the present meeting. An interesting résumé was given here as to the origin of fireclays, and it was shown how difficult it was to establish a relation between their fusibilities and compositions based merely on ultimate analysis. "Mechanical" analysis was first necessary, and the material divided up into kaolin, or true clay substance, quartz, and feldspar. Of these the first, $Al_2O_3 \cdot 2SiO_2$, is the most infusible. The amount of accompanying fluxes, iron oxides, lime, magnesia, potash, and soda—which flux in the ratio of their equivalent combining weights—is, however, a very important factor.

The address next dealt with the classes of refractories in use, namely, acid, basic, and neutral, and the special properties and use of each were indicated. The comparatively new refractory zirconite was discussed in somewhat fuller detail. A series of exhibits illustrated some differences in practice between good and bad refractories. Thus the diameter of a magnesite nozzle remained quite unaltered at 1 in. even after 28 tons of steel had been poured through it, whereas that of an ordinary fire-clay nozzle increased to 2 in. The difference might well represent slag embedded in the steel.

Some photomicrographs were shown, illustrating the use of microscopy in the study of refractories, and the address concluded with a bibliography of papers and books and with a series of tables giving complete analyses, largely compiled from the author's own records, of most of the refractories in common use.

The opening paper of the symposium was given by Dr. J. W. Mellor (Stoke-on-Trent), and it dealt with "The Texture of Firebricks."

What constitutes a good firebrick is a favorite question, and one which does not admit of a satisfactory answer. The requirements from firebricks vary so widely in different furnaces, or in particular parts of a single furnace, that the ideal firebrick can be defined only in abstract terms, and this the more because some properties can be highly accentuated only at the expense of others.

Texture is one of the most important qualities of a firebrick, since, assuming that the chemical composition and refractoriness are otherwise satisfactory, the life and character of the firebrick are largely determined by its texture. The texture of a refractory may vary from that of the light porous bodies used in making bricks for insulating boilers, etc., to non-porous or vitreous bodies used in making crucibles, acid-resisting bricks for acid towers, etc. There are quite a number of intermediate types. The different types of texture were exhibited. The samples were prepared by cutting the brick transversely, polishing an exposed face, and finally cementing a glass plate on the polished faces by means of hot Canada balsam.

It was shown that the refractoriness of a firebrick under ordinary conditions of measurement is dependent to a small extent on the grain-size. The after-contraction of firebricks and the after-expansion of silica bricks is due to the arresting of the changes which occur during the firing of a brick before they are completed.

For bricks which have to resist the abrasive action of streams of flue dust, coal ashes, slags, etc., a close texture is necessary; but a close-textured brick is liable to split with abrupt variations of temperature. To reduce the tendency to splitting in this way, a uniform texture is desirable. The chemical composition of the brick in relation to that of the dust and slag it has to resist at high temperatures is of great importance. Examples illustrating the importance of both texture and chemical composition were shown. In slags which exert a severe action on the firebrick, the importance of small well-fitting joints, cemented by a good jointing clay, was also emphasized, since with bricks having a close uniform texture and the right chemical composition the joints are the weakest places.

Other examples were also given, showing that the texture of a firebrick is as important as chemical composition and refractoriness. The texture is a property which can be largely controlled by the manufacturer, whereas the other qualities are not so amenable to treatment. It was shown, by using the blast furnace as an illustrative example, that the consumer must carefully consider the conditions which prevail in different parts of any particular furnace before he selects for trial particular types of texture as likely to suit particular parts of his furnace.

Professor W. G. Fearnside (Sheffield) spoke principally on "The Application of Petrographic Methods to the Study of Refractory Materials."

By way of introduction Professor Fearnside called attention to the circumstance that, though there is a woeful lack of scientific data to help makers of refractory materials who are starting a new line to command certain success in any one of the manufacturing processes involved in the making of a brick, there is among the foremen brickmakers and furnacemen a great deal of information which only needs to be collected, codified, and interpreted to make it as scientific as the best laboratory product. One of the most pressing necessities in refractory material manufacture at the present time is for scientific workers to go through the works and listen when practical men bring

out information in terms which are the language of the brickyard or the foundry, and which they should translate and express in the international language of time and inversion-temperatures of grain-sizes and chemical compositions which are the usual currency of those superior people, who think they know. A great deal might also be accomplished if actual makers who have obtained a measure of success and users who are subjecting the material manufactured to unusual stress would work together and face awhile each the other's difficulties; and if, alongside, there might be a competent and sympathetic man of science who would stand by and hold the balance and occasionally give his help to spoke a wheel, the progress of the refractory-making industry would be more rapid than many people think. Though in its best developments the art of making refractory materials is in advance of the science, the practice of the art, by unskilled makers, leaves much to be desired, and it is certain that out of a scientific study of the craftsman's methods would come experience, in the light of which repetitive practice might, with advantage, be scientifically controlled.

Referring to the application of the microscope to the study of refractory materials, Professor Fearnside recalled the pioneer work done by the late Henry Clifton Sorby, of Sheffield, who some fifty years ago, in the course of his early work on the physical constitution, first of rocks and afterwards of metals, rubbed down preparations both from silica bricks and firebricks to a condition of fair transparency. In determining the texture of any brick the thin slice method is one of direct and easy application. In the study of the relationship between the plums and the porridge which together make up a brick, great skill of manipulation is required to bring the method to any great success. Attainment of a technique which will make evident the character of the "binder" has offered greater difficulties than either the slicing of rocks or the preparation of polished and etched surfaces of almost any metal. These difficulties, however, should not be insuperable, and in a brick made from basic materials in which high refractive-index is a characteristic property (e.g. magnesite, chromite, shrunk-bauxite, zirconia, and the like), one knows enough already to judge at a glance the measure of success which the brick manufacturer has attained, and with experience to guide one it is not difficult to foretell approximately how particular batches of bricks will behave in the furnace. With new-made silica bricks, and especially with firebricks, the determination both of the composition and of the intrinsic structure is not so easy, and with slices of normal thickness (between 1/500 and 1/1000 of an inch), new formed materials are in such tiny crystals that they generally interfere one with another and appear as a felted mass. Characteristic inversions of quartz to tridymite and cristoballite in silica bricks are comparatively easy to observe, and from structures revealed by the petrographical microscope one can determine with fair accuracy the heat treatment which a silica brick has received. More satisfactory, however, from the point of view of demonstration specimens, are micro-preparations cut from the bricks turned out from the linings of large furnaces when those furnaces are dismantled at the termination of their run; and probably it is by careful selection and the scientific study of the more successful of these highly metamorphosed end products that scientific workers will first gain information which may suggest a probable direction for the manufacturer's next advance.

At this point the president asked Dr. R. Lessing to show a series of specimens illustrating a method of

testing he had devised five or six years ago for ascertaining the texture and rational composition of refractory mixtures before firing.

The method consists of a simple process of elutriation, by which the true clay substance of the "green" clay is removed by a gentle current of water and separated from the water by allowing it to settle out on standing. The rate of flow of water is so adjusted that the "grog," i.e. the previously fired portion of coarse particles which eventually forms the rigid skeleton of the firebrick, and also the heavy and coarse grain residue of the "green" clay, consisting of sand, shale, or carbonaceous substances, are left behind in the elutriating vessel.

Elutriation is continued until the last clouds of clay substance are removed and the water becomes perfectly clear, with the lightest portions of the residue floating just below the outlet.

A very simple form of elutriator, accurate enough for works purposes, consists of a tall glass cylinder into which the water is passed through a glass tube reaching nearly to the bottom. The cylinder is placed in a bucket, into which the clay suspension overflows, and to which the clear water is syphoned off after settling. For the purpose of the test about 500 grams of the sample (which may be taken before or after "tempering" or from a molded body before or after drying) are well soaked in water and washed into the cylinder. The resultant products of clay and residue are dried, and a grading test is then performed on the residue, from which the texture of the body and the ratio of grog, granular clay, shale, and coal can be ascertained.

The specimen exhibited showed that before the standard specification was adopted mixtures for gas retorts contained very little grog, which had, moreover, suffered largely from excessive crushing, yielding dust, whilst the "green" clay serving as binder had largely remained in the form of coarse granules instead of being reduced to fine powder. The change in manufacturing methods by which the "grog" is crushed and graded separately and the powdered "green" clay mixed with it were shown by specimens taken after the adoption of the standard specification. For comparison a sample of a German retort mixture was shown, which was remarkable for its large proportion and size of grog, viz. 66 per cent, as against 35 per cent in English retorts, and also for the total absence of clay residue, shale, or coal, indicating that the binding clay had undergone some preliminary purification.

The test has been used successfully for the daily control of manufacturing operations, and is recommended by the author for this purpose, and in the absence of a reliable quantitative method for ascertaining the texture and rational composition of refractories is a simple and useful guide.

Dr. H. G. Colman gave a short account of the work on Refractory Materials carried out by the joint committee appointed on the subject by the Institution of Gas Engineers and the Society of British Gas Industries.

This committee, consisting of representatives of both the users and manufacturers of refractory goods for gasworks purposes had, after determination of the conditions prevailing in gas-retort settings under present day conditions, drawn up provisional specifications relating to the different classes of fire-resisting goods commonly in use in gasworks, namely, retort material, ordinary firebricks and silica bricks, prescribing, among other more general matters, the physical tests with which these goods must comply. In addition, the

committee were carrying out investigations on matters likely to be of value to both users and manufacturers and to assist in the provision of the fire-resisting materials most suitable for the above purposes; the means at their disposal, however, had not enabled them as yet to make more than a commencement of the work in this respect, investigations being now in progress on points such as the effect of pressure on the refractoriness of materials, the relative effects of an oxidizing and reducing atmosphere, and the influence of the fine flue dust carried into the hot setting on the life of the materials employed.

Mr. J. Allen Howe made a statement on the "Recent Work of the Geological Survey on Refractory Materials."

The statement indicated what the survey has done since the war in preparation for the forthcoming report on British Refractory Materials. The country has been blocked out into field-areas, and from each samples of raw materials have been secured and classified, the geological character of their locality and the nature of the deposits having been exactly noted. In each main center both producers and users of refractory materials have been consulted. The main groups of material may be classified as the silica group, the fire-clay group, refractory sands, and dolomite, and the report will probably be issued in corresponding sections. Well over 1500 samples have so far been received, and the collection of the raw material—the first stage of the work—is almost completed. The next stage, putting into shape the field-notes and the chemical, petrological, mineralogical, and textural examination of the specimens, is already well advanced. Arrangements are being made to test the refractoriness and determine other physical characteristics of the materials, and the data so obtained will be included in the report.

Dr. A. Strahan, director of the Geological Survey, supplemented Mr. Howe's statement. After a reference to the practical value of the 6-in. survey maps, he emphasized that the report will tell manufacturers exactly the extent and nature of the reserves of refractory minerals in this country, and specimens for examination will be available in the museums. A selection from the samples collected was exhibited at the meeting.

Mr. T. Crook, of the Imperial Institute, in commenting upon the specimens exhibited by Dr. Wyndham Dunstan, director of the Institute, stated that Great Britain was well provided with resources in the less common refractories, such as graphite, in India and Canada; chromite, which is abundant in Rhodesia and India; magnesite in Victoria, South Africa, and British Columbia; bauxite in India and British Guiana, and zircon in Natal.

Mr. Cosmo Johns (Sheffield) dealt with the "Use of Silica as a Refractory Material in Steel Manufacture."

After briefly referring to the use of refractory sands and the advantage of small amounts of impurity, the status of the silica or Dinas brick was discussed. He pointed out that owing to the fact that the raw material of the industry was never pure, the brick itself was a mineral aggregate of extreme complexity, and owing to the absence of exact knowledge as to its thermal history, it could not be treated from the simple standpoint of the binary system lime-silica. Its constitution at high temperature could not be predicted from a petrological study of the brick before or after use in our present state of knowledge. The important changes it undergoes during long service under furnace conditions, with the accompanying absorption of magnetic oxide of iron were mentioned, and it was

suggested that though the magnetite was possibly only an indicator signifying the nearer approach to equilibrium of the original components at the high temperatures the brick had been subjected to for a long period, the possibility that the magnetite was not a passive agent was not excluded. It was suggested that the lines along which investigations might be made with the prospect of early and useful results would be the study of the effect of texture by varying the grain-size and correlating texture with such physical properties as refractoriness and ability to withstand variations of temperature. When the most suitable texture had been decided upon, the investigation of the time-temperature curve during burning of the brick could be undertaken.

Mr. Albert Cliff (Stamford) spoke "On the Manufacture of Refractory Materials," putting forward in a general way the makers' point of view.

Various suggestions were made as to the directions in which improvements in manufacture were possible. One was in the reworking up of old material; this would be one of the best means of eliminating expansion and contraction. In the basic and neutral groups of refractories there was an inviting prospect for the application of manufacturing skill. Some of the present temporary difficulties in the supply of materials he himself was overcoming by fastening working surfaces of chromite, magnesite, or other materials not liable to corrosion on to ordinary fire or silica bricks. Some samples of these faced bricks were exhibited. As a manufacturer he advocated the closest possible union between the chemist and the craft in the carrying out of organized investigations—mere laboratory tests were insufficient—into the commercial value of the minerals, chromite, magnesite, graphite, and others, reported that evening as abundant in the colonies. Above all, improved education was necessary in those who were to carry on the business of making refractories; the men of science must come down to them and talk to them freely of principles and facts, and so accelerate a rise of specialized intelligence among clayworkers.

Mr. E. P. Page (Sheffield), who spoke on "The Classification of Refractory Materials and Some Notes on Method and Points for Investigation," briefly introduced his paper as follows:

This paper is confined in the main to the materials used in the heavy industries. To cover the whole field of refractory materials and their application in large branches of industry would be beyond the range of accomplishment in any single paper. The collection and tabulation of facts is a laborious task, since much of the information is only to be obtained by the association of those who are engaged in industrial practice. Further, the science of refractory materials is in its infancy, and much of that which is considered to be the fact requires verification. An easy method of classifying refractory materials has been to divide them into three sections, namely, acid, basic, and neutral, according to their chemical composition and their behavior toward each other and the acid or basic compounds brought into contact with them under such conditions as are favorable for reaction to take place. The classification is somewhat arbitrary, because a clay such as china clay must be expected from its chemical composition to be a neutral material, which experience shows is not the case, and it is customary to include all refractory clays in the acid class. The essential property of any material claimed to be refractory is stability at the temperatures to which it is exposed, with sufficient reserve of stability to resist chemical and mechanical influences externally applied. The first quality is a classification of pure refractory-

ness, and the second is one of refractoriness plus skill in application. However, since purely basic or purely acid conditions seldom exist, the successful issue is generally the result of compromise, a certain degree of refractoriness per se being sacrificed in favor of an increase of refractoriness against other things. Materials belonging to the acid class are always used where it is a case of refractoriness toward heat, because they are widely distributed and comparatively low in first cost and lend themselves rightly to adaptation to all purposes. Suitable basic and neutral materials, on the other hand, are not so widely distributed, and possess in important instances inherent properties which render them difficult of application.

Mr. W. J. Jones, of the Ministry of Munitions, said the discussion had brought out clearly the necessity for closer co-ordination between science and practice, between the laboratory on the one hand and the brick-maker and the steel-maker on the other. It was the enormous increase of production necessitated by the war that had brought home to the steel industry the importance of their refractory materials. He urged as a further reason for co-ordination the different results that so often were obtained with the very same material in different works.

Mr. A. A. McDougall Duckham of the Ministry of Munitions, also emphasized how much the output of munitions depended on refractories. It was clear that Great Britain had at home and in the Empire ample material to enable us to hold our own.

Dr. W. Rosenhain, of the National Physical Laboratory, spoke of the necessity for paying attention to the highest class of refractories now that metallurgists, especially in the electric furnace, were utilizing very high temperatures. Metallurgists should know all about materials like carborundum, alundum, silicon and similar products now being produced at Niagara Falls. There was great promise in zirconia, especially the highly purified material. An analysis of crude zirconia (about 75 per cent pure) was given. This material fell far short of pure ZrO_2 in refractoriness, but still bricks made of it would resist temperatures up to 1600 deg. C. To get the best results it was essential to shrink the material at a much higher temperature than that it would have to stand eventually, particularly because it was so bad a conductor of heat. The crude zirconia was greatly improved by removing the chief flux, namely the iron oxide, with hydrochloric acid. Zirconia bricks as now purified for optical purposes do not frit until well over 2000 deg. C. Dr. Rosenhain went on to discuss the cracking of refractories. This was caused by physical forces involving nothing but determinable constants, and the co-efficient of thermal endurance could be worked out, as had been done for glass.

Professor T. Turner (Birmingham) reminded the meeting that the subject was also of interest to the glass, pottery, and porcelain industries, and he referred to the work on glass being done at Sheffield University. Speaking of the relation between porosity and the packing of the grains of which the material is built up, he pointed out that round grains did not necessarily mean an open and sharp a close packing. Small round particles in the interstices of larger round ones, as one might have in sand, gave the closest grain. Porosity had been measured by drawing air through at a known rate.

Dr. R. S. Hutton (Sheffield) pleaded for more work at the very high temperatures of the electric furnace. For example, the properties of completely shrunk magnesite were quite different from those of ordinary calcined, and the shrinking could be economically effected electrically.

Dr. W. H. Hatfield (Sheffield) remarked on the work to be done on the resistance of refractories to slag erosion. He gave examples of the great disparity in behavior of different grades of silica bricks. Before more progress was possible much more accurate instruments for registering high temperatures were necessary; at present, calibration between 1000 deg. and 2000 deg. C. was difficult and uncertain.

Professor F. G. Donnan spoke of the necessity for a standard quantitative specification for silica bricks.

Dr. P. G. H. Boswell, of the Geological Department, Imperial College of Science and Technology, read a paper on "Refractory Sands."

Many of the sands used for refractory purposes are not true sands in the geological sense; they frequently contain a proportion of refractory clay, etc. There is no doubt that we can replace from home resources a large proportion of the refractory sands hitherto imported from abroad, but the extent to which this can be done will not be completely known until further investigation of the properties of suitable materials and satisfactory substitutes has been carried out. The admirable work of H. M. Geological Survey in collecting, recording, and, in part, subjecting to analysis supplies of refractory materials worked in this country needs to be supplemented by much research work, for in certain directions the properties of desirable sands, for example, are not fully known, and geologists do not know what to look for. Pure academic work in the shape of the application of modern petrographic methods to the investigation of sands is urgently required, but the final tests of the suitability for particular purposes must always be on a commercial scale in the works. On the academic side, we need far more results of experiments and observations carried out on certain definite lines and under standard conditions with continuity secured by the retention of one worker or set of workers in each direction. The time has passed for the scattered and haphazard methods and results of which we have had so large a number. The pure scientific work will indicate the likely materials to be tried in industrial practice and will eliminate the improbable materials. The closest British analogues to the very suitable foreign materials will then be found.

The refractory sands used in industry may be divided into three chief classes: (a) the high silica sands (with 98.99 or more per cent of SiO_2), (b) the high silica and alumina sands bearing variable proportions up to 20 per cent alumina, as kaolin, etc., and little else but silica, (c) sands for greensand-molding, carrying a strong and highly refractory natural clay bond. All class (a) sands hitherto imported may be replaced from the abundant and excellent British supplies. (The economic factors, freight, etc., will have to be considered.) We have also valuable deposits of class (b), but so far as those sands of class (c) which are used for high temperature steel-molding are concerned, it must be admitted that the best of foreign sands hitherto used here have not been equalled by known British resources. The reason for this is twofold: in the first place the peculiar properties of the Belgian red or yellow sands, to take a concrete case, have never been thoroughly investigated with the view of finding substitutes; in the second, we do not yet know all our British sand and related deposits at all thoroughly. At least two geological horizons in this country should be thoroughly searched in this connection: they are the Pliocene and the Lower Cretaceous. The Tertiary and Cretaceous deposits of the southwest of England are particularly deserving of attention.

In brief, research on British and foreign refractory

sands is desirable in the following directions (among others):

- (1) Mechanical analyses, to gain more accurate ideas of grading, carried out scientifically.
- (2) Chemical analyses of each grade, not bulk analyses.
- (3) Mineral analyses, to realize the importance of constituent minerals, especially those prone to decomposition which yield the "bonds" of these sands.
- (4) The water-holding capacity at 10 deg. intervals at temperatures below 110 deg. and at suitable but greater intervals above.
- (5) The conductivity.
- (6) The refractoriness of each grade.
- (7) Pore space and permeability.

It is to be hoped that before long a detailed account of British resources of refractory sands, with analyses and notes on their peculiar properties, may be in the hands of manufacturers and others. Such a report by the speaker on British resources of sands suitable for glass-making, with notes on certain highly siliceous materials suitable for refractory purposes, was just being published at the request of the Ministry of Munitions. These glass-sands fall under classes (a) and (b) above, but the resources suitable for refractory purposes are far larger than those for glass-making.

Finally, co-ordination of the work of the four classes of interested people (users of refractories, the makers of refractories, the collectors and analysts of raw materials, and the research workers) is urgently required to prevent serious overlapping and to insure a minimum loss of effort and a maximum of benefit to the country, which as far as possible should be self-supporting in the matter of raw materials for key-industries.

The general discussion was resumed by Mr. E. Kilburn Scott, who confirmed from his own experience with flame-arc furnaces what Dr. Hutton had said about the possibility of completely shrinking magnesite.

Dr. W. C. Hancock spoke of the application of certain organic dyes to etch refractory materials much as metals were etched. This method, coupled with Professor Fearnside's, would be a powerful weapon for elucidating internal structure. He was working on coke-oven firebricks in this direction in conjunction with Professor Bone at the Imperial College of Science and Technology.

Here the president called on Mr. Ezer Griffiths of the National Physical Laboratory to read his paper on "The Thermal Conductivity of Materials employed in Furnace Construction."

The paper dealt with the methods employed for investigating the thermal conductivity of bricks and tiles of commercial sizes.

One of the practical difficulties was the attainment of a uniform temperature over the hot face of the sample, since the surfaces were always irregular. It was found possible to obtain good thermal contact as well as a very uniform distribution of temperature over the surface by the use of a shallow bath of molten metal electrically heated.

In high temperature experiments the heating was effected by making the test sample a part of the walls of a large muffle.

The heat transmitted was measured by a flow calorimeter fitted with a guard ring.

A compact form of thermoelement was described: the two wires (Pt — Pt 10 per cent Ir) being separately insulated by silica capillaries and both inclosed in a silica sheath of about 5 mm. diameter. The sheath was closed at the end in the form of a bulb containing the junction. The thermoelement was em-

ployed for exploring the distribution of temperature in the metal bath, and for this purpose it was bent into an L shape.

Values of the thermal conductivity and its variation with temperature were given for two typical materials employed for thermal insulation—the one composed principally of diatomaceous earth baked at a high temperature to form a rigid brick of friable texture; the other manufactured by blowing steam through molten blast-furnace slag, which converts it into a product bearing a resemblance to cotton-wool. This material was tested in the form of a mat, the faces being covered with wire meshing.

Dr. J. A. Harker commented on the value and accuracy of Mr. Griffiths' work on a subject presenting serious experimental difficulties.

He added some information on the properties of zirconia, which, if fine enough, would stand being plunged into water at a white-heat temperature.

Written communications to the discussion were received from the following gentlemen:

Mr. W. Donald (Glasgow), who sent in some specimens of raw and calcined Greek magnesite and magnesite cement and bricks, wrote that they were having to make substitutes for Austrian magnesite bricks, and they were therefore adding some 8 per cent Fe₂O₃ to the Greek magnesite, which was too pure, to approximate its composition to the Austrian. Mr. Donald also exhibited some Indian and Rhodesian chrome ore and cements and bricks made therefrom. He went on to suggest that the use of dolomite in conjunction with magnesite for basic steel furnaces needed serious consideration. He believed that when, as often, the dolomite boils with the metal active ferrates of lime may be formed, and the result is destructive to the magnesite foundation of the furnace. He had recently suggested to the Iron and Steel Institute the desirability of drawing up standard specifications for bricks used in the iron and steel industries. Finally, he touched on the question of linings for electric furnaces, and he incidentally mentioned the possibilities of Serbia, with its minerals and plentiful water power, as an electrometallurgical center.

Mr. A. B. Searle (Sheffield) expressed his agreement with the view that chemical analysis was secondary in importance to some of the physical characteristics of firebricks, and he had himself chiefly relied on physical and microscopical methods of examination. Referring to the desire for co-ordination that had been expressed, he reminded the meeting that they had a trade journal which devoted special attention to the scientific and technological aspects of refractories. Packardness was largely due to the fact that most of the firms concerned were too small to undertake research work. Furthermore, research, to be useful, must be carried out by specialists who had practical knowledge of the industry. The manufacturers should combine together and retain such men, leaving the universities to concentrate on questions of academic interest, for which they were specially fitted.

Mr. T. Allen (Dudley) said the great difficulty in making improvements in manufacturing process in this industry was to prove the value of any change, because this might take years to realize. Laboratory tests were often inconclusive. Nevertheless, the gas-retorts of to-day were meeting the severe demands put upon them. An important point was the economy of not running retorts after their efficiency has dropped, say in 1000 to 1200 days. He did not think German or American gas installations showed better results than the best of the British. He paid a tribute to the work of the Refractory Materials Committee.

Mr. F. Deansfield (Oldham) wrote of the desirabil-

ity of inducing manufacturers to adopt more uniform methods. He also drew attention to the enormous loss of refractory clays lying under coal seams, due to the winning of the coal only, so that it afterwards becomes too dangerous and costly to win the clay. These materials should be carefully reserved, if necessary by legislation. He hoped the society would consider this problem.

Mr. Alleyne Reynolds wrote that he knew of an Austrian works having clamped arches of silica brick 8 ft. in width that had been in use for over twenty years, whereas we were satisfied to produce silica bricks with 20 per cent expansion. The same firm paid more attention to properly heating their ladles and shaping their nozzles than any British firm of his acquaintance. There should be more co-operation between the steel makers and the makers of refractories. The keeping of so-called "trade secrets" was to be deprecated; the most successful manufacturers were those who showed, like their president, a large-minded scientific spirit. Mr. Reynolds disagreed with the president as to worn clay nozzles accounting for slag inclusion in steel ingots, which he thought resulted from reactions in the dissolved FeO and FeS. He was suspicious of magnesite nozzles, from which minute particles would probably be carried into the mold. He added some interesting information on the proper method of casting steel from the ladle and on the effect of iron oxides in firebricks. Fe₂O₃ and FeO seem to increase the refractoriness of bricks exposed to oxidizing atmospheres; any iron oxide is detrimental in reducing atmospheres. The bricks forming the regenerators of open-hearth furnaces take up much more iron in the gas than in the air chambers, and their regenerative efficiency is increased. The subject needs proper investigation, as does also the volatilization of refractories, particularly magnesite, at low temperatures, such as 1300 deg. C., perhaps due to catalytic action. A properly designed electric furnace was, he thought, the only remedy.

Mr. Charles R. Darling in view of the relatively high conductivity of firebricks as shown by Mr. Griffiths, drew attention to the suggestion of Hutton and Beard, made before the society in 1905, that furnaces should be lagged with a highly insulating substance. Experiments by FitzGerald and by him had confirmed the great saving anticipated. It was strange that metallurgists had not adopted the idea.

A very useful refractory was alundum, of which Messrs. Baird and Tatlock exhibited specimens. It melted at 2050 deg. C. and had no action on platinum at high temperatures, so was suitable for platinum-wound electric furnaces. A non-porous variety was useful for sheathing pyrometers and is less corroded by molten metals than silica. The question of the electrical conductivity of refractories had been little studied; in a research he was engaged upon he needed one that was non-conducting at 1600 deg. C., and which was not easily attacked by metallic oxides.

Standardization of Carbon Electrodes for Furnaces.—From the *London Electrician*, Nov. 17, we learn that as a result of war conditions in Germany carbon electrodes for electric furnaces are now being standardized. According to the new rules round carbons for steel furnaces are to be made in sizes varying in thickness from 100 mm. upward by steps of 25 mm., the tolerance varying from 3 mm. to 6 mm. according to size. For rectangular electrodes used with other kinds of furnaces a standard size of 500 mm. square is proposed. For the time being the standard length is fixed at 2 meters, but all lengths may be valued in multiples of 20 mm. Tables for dimensions of threads are under consideration.

New York Meeting of American Association for the Advancement of Science and Associated Societies

The sixty-ninth meeting of the American Association for the Advancement of Science will be held in New York City from Tuesday, Dec. 26, to Saturday, Dec. 30. Of the general addresses on the program three are of especially great importance. On Tuesday evening the retiring president, Dr. W. W. Campbell, of Lick Observatory, will deliver his address on "The Nebulae." On Wednesday evening Dr. Simon Flexner, of Rockefeller Institute, will speak on "Infantile Paralysis." On Thursday evening Prof. A. A. Noyes, of Massachusetts Institute of Technology, will speak on "The Production of Nitrogen."

SYMPOSIUM ON STRUCTURE OF MATTER

Sections B (Physics) and C (Chemistry) of the A. A. A. S. will hold a joint meeting with the American Chemical Society, the American Electrochemical Society, and the American Physical Society on Wednesday, Dec. 27, at 10 a. m. and 2 p. m. at Columbia University.

The morning session will be opened by the address of the President of the American Physical Society, Robert M. Millikan, on "Radiation and Atomic Structure." Papers will then be presented by Gilbert N. Lewis on "The Atom and Chemical Valence," by Robert W. Wood on "Molecular Resonance and Atomic Structure," and by Irving Langmuir on "The Atomic Theory." The discussion will be opened by Wm. Duane and John M. Nelson.

In the afternoon session papers will be presented by William J. Humphreys on "The Relations of Magnetism to the Structure of the Atom," by Albert P. Wills on "The Relations of Magnetism to Molecular Structure," by Wm. D. Harkins on "The Evolution of the Elements as Related to the Structure of the Nuclei of Atoms," and by Lander W. Jones on "Electromerism, a Case of Chemical Isomerism Resulting from a Difference in Distribution of Valence Electrons." The discussion will be opened by K. George Falk.

On Thursday, Dec. 28, at the College of the City of New York, the retiring vice-president of Section C (Chemistry), Prof. William McPherson, will deliver his address on "Asymmetric Syntheses and Their Bearing Upon the Doctrine of Vitalism."

Section D (Engineering) of the A. A. A. S. will hold a session in the Engineering Societies Building, 29 West Thirty-ninth Street, on the invitation of the American Society of Civil Engineers, the American Institute of Electrical Engineers, the American Society of Mechanical Engineers, and the American Institute of Mining Engineers. At this meeting Dr. Bion J. Arnold will deliver his address as retiring chairman of Section D, and there will be addresses by representatives of the engineering societies, followed by a reception to engineers and those working in sciences relating to engineering. This meeting will be held on the evening of Friday, Dec. 29.

An exhibition of chemical and physical products and apparatus will be held at Columbia University on Wednesday, Thursday, and Friday, Dec. 27, 28 and 29.

The J. P. Devine Company, Buffalo, N. Y., has issued bulletin No. 105 describing apparatus for the chemical and allied industries, including autoclaves; reduction, nitrating, fusion and tilting kettles; vacuum pans, vacuum evaporators, jacketed pans for drying, evaporating and crystallizing; digestors, and other chemical apparatus. Most of the illustrations are shown in perspective and are quite attractive.

The Electrolytic Oxidation of Sulfurous Acid

By M. De Kay Thompson and N. J. Thompson

The electrolytic oxidation of sulfurous acid gas is a process that may become of technical importance because of the increasing use of unattackable anodes in winning copper direct from the ores. If sulfur dioxide is supplied to the anode, the voltage is reduced because the dioxide acts as a depolarizer, and is itself oxidized to sulfuric acid. There seems to have been very little work done in the study of this reaction.

The use of sulfur dioxide as depolarizer in the recovery of pure copper from copper sulfate solution obtained by leaching the copper ores was patented in 1902 by Tossizza (U. S. Patent No. 710,346), but no information is given as to the current efficiency of the oxidation. The only other reference we have found is an article by A. Fischer and G. Delmarcel, entitled "L'Oxidation Electrolytique de L'Acide Sulfureux" (Chem. Zentralbl. 1910, ii, p. 603; Bul. Soc. Chim. Belgique 24, pp. 236-37). The authors used an earthenware cup as diaphragm, containing a cylindrical nickel cathode and a cylindrical platinum gauge anode surrounding the diaphragm. The porous cup was filled either with sulfuric acid or sodium sulfite. Outside the cup there was a solution or sulfur dioxide, the concentration of which varied from 1 to 5 per cent. The current density was about 0.0075 ampere per square centimeter. They found that catalysts, such as copper acetate, do not increase the current yield in sulfuric acid, since the platinum acts as a catalyst itself. Better results were obtained with low than with high concentrations of sulfur dioxide.

In the following experiments the anode solution was kept saturated by passing a current of sulfur dioxide, and absorbing the excess in a soda lime 1.2 centimeters in diameter and 38 centimeters long. This absorbs the dioxide, but allowed any oxygen formed in the electrolysis to pass.

The dioxide was made by the action of sulfuric acid on copper wire, 1.8 millimeters in diameter. The rate of evolution was controlled by regulating a gas burner under the 500 cubic centimeter generating flask. The dioxide was washed in a solution of sulfurous acid and then passed to the anode compartment of the cell, which consisted of a porous cup, 5 centimeters in diameter and 15 centimeters high. The cup was glazed at the top inside and outside and was closed by a rubber stopper with holes for the supply and delivery of gas and for the anode connection.

The anode was a sheet of smooth platinum of 25.8 square centimeters, including both sides. The sulfur dioxide tube delivered immediately under this electrode. The cathode was a nickel cylinder, surrounding the porous cup. The whole was contained in a glazed porcelain vessel of the smallest possible size.

The cell was cooled by placing in a pail where water circulated. The temperature of the cathode solution was 20 deg. C., the anode solution was about 5 deg. higher.

The gas coming from the anode compartment passed the soda lime tube referred to above and then passed to a Hempel burette with a three-way stop cock by means of which the oxygen could be measured continuously before allowing to escape. The oxygen generated represented a current loss, and was used as a measure of this loss.

Any oxygen in the gas escaping from the anode compartment must be due to a liberation of sulfate ions which react with the water present. There could have been no reactions other than this or the oxidation of sulfurous acid, for the only other reaction pos-

sible is the union of two sulfate radicals to form persulfuric acid. This acid, however, is formed only at low temperatures and with the simultaneous evolution of oxygen. Moreover, it could not be formed in the presence of a strong reducing agent like sulfurous acid.

The method of experimenting consisted in making up solutions of sulfuric acid of different concentrations, with which the cell was filled, both anode and cathode compartments. The electrolysis was then carried out with different current densities from 0.19 to 0.50 ampere per square centimeter. Before starting each run, sulfur dioxide was passed through the system (except the soda lime tube) for about an hour to remove all the air.

The total amount of electricity passing the cell was determined by a copper coulometer. The current efficiency was determined by computing the amount of copper equivalent to the total oxygen evolved, subtracting this from the copper deposited in the coulometer and then dividing by the copper deposited.

The results obtained are tabulated below and are shown in Fig. 1.

DATA (OBSERVED AND CALCULATED)

RUN NO. 1. 10 PER CENT H_2SO_4 . BAROMETER, 761 MM. TEMP., 22.0 C.

Conc'n	Voltage	Coulometer Weight	Voltage		Current Efficiency
			Obs.	Calc.	
5.0	3.00	2.61	No gas		100.0
5.0	3.00	1.21	No gas		100.0
7.0	4.20	2.34	No gas		100.0
7.0	4.10	1.58	No gas		100.0
9.0	4.30	1.44	No gas		100.0
9.0	4.25	1.22	No gas		100.0
11.0	4.45	1.08	No gas		100.0
11.0	4.30	1.07	0.6 cc	0.6	99.5
13.0	4.50	1.11	1.2	1.1	99.5
13.0	4.45	1.19	0.9	0.8	99.7

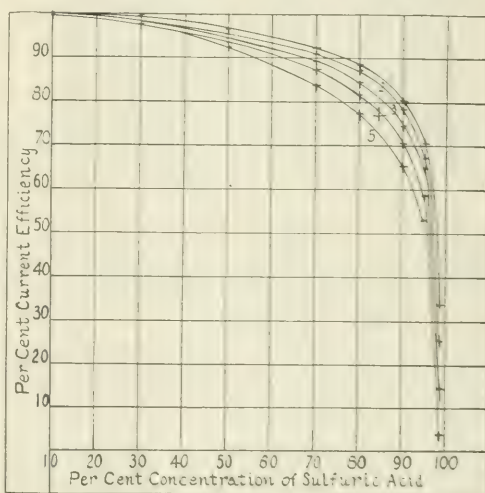


FIG. 1—SHOWING THE RELATION BETWEEN CURRENT EFFICIENCY, CURRENT DENSITY AND CONCENTRATION OF SULFURIC ACID IN THE ELECTROLYTIC OXIDATION OF SULFUROUS ACID. THE CURRENT DENSITIES WERE 19, 27, 35 AND 50 AMPERES PER SQUARE DECIMETER FOR THE GRAPHS 1 TO 5 RESPECTIVELY

RUN No. 2. 30 PER CENT H₂SO₄. BAROMETER, 761 MM. TEMP., 22.0 C.

Current	Voltage	Coulometer Weight Cu.	VOLUME OF OXYGEN		Current Efficiency
			Obs.	Corr.	
5.0	4.15	2.38	2.1	1.9	99.5
5.0	4.15	1.09	1.0	0.9	99.5
7.0	4.50	3.74	15.3	13.8	98.0
7.0	4.40	1.19	4.9	4.4	98.0
9.0	4.85	2.04	7.3	6.6	98.2
9.0	4.75	1.18	4.2	3.8	98.2
11.0	5.05	1.74	7.2	6.5	97.9
11.0	5.05	1.04	4.3	3.9	97.9
13.0	5.35	1.59	7.5	6.8	97.6
13.0	5.30	1.18	5.6	5.1	97.6

RUN No. 3. 50 PER CENT H₂SO₄. BAROMETER, 761 MM. TEMP., 22.0 C.

Current	Voltage	Coulometer Weight Cu.	VOLUME OF OXYGEN		Current Efficiency
			Obs.	Corr.	
5.0	4.15	1.75	12.2	11.0	96.5
5.0	4.10	1.20	8.3	7.5	96.4
7.0	4.55	2.38	21.4	19.3	95.5
7.0	4.45	1.12	10.2	9.2	95.5
9.0	4.95	0.94	10.6	9.5	94.5
9.0	4.90	1.01	11.2	10.2	94.4
11.0	5.25	1.46	19.0	17.1	93.5
11.0	5.15	1.15	14.9	13.5	93.3
13.0	5.50	1.24	18.1	16.3	92.6
13.0	5.40	1.13	16.5	14.9	92.6

RUN No. 4. 70 PER CENT H₂SO₄. BAROMETER, 750 MM. TEMP., 230 C

Current	Voltage	Coulometer Weight Cu.	VOLUME OF OXYGEN		Current Efficiency
			Obs.	Corr.	
5.0	4.80	1.64	23.6	21.1	92.7
5.0	4.70	1.01	14.4	12.9	91.8
7.0	5.60	1.66	29.3	26.3	91.0
7.0	5.30	1.21	21.4	19.2	91.0
9.0	6.75	0.778	17.0	15.2	89.0
9.0	6.70	0.811	17.7	15.8	89.1
11.0	6.80	1.044	26.6	23.9	87.1
11.0	6.80	0.997	25.5	22.8	87.0
13.0	7.60	1.29	40.8	36.6	83.8
13.0	7.70	0.910	28.8	25.8	83.9

RUN No. 5. 80 PER CENT H₂SO₄. BAROMETER, 761 MM. TEMP., 22.0 C.

Current	Voltage	Coulometer Weight Cu.	VOLUME OF OXYGEN		Current Efficiency
			Obs.	Corr.	
5.0	5.05	0.842	19.0	1.71	88.5
5.0	5.00	1.09	23.5	21.2	88.5
7.0	5.90	0.851	21.6	19.4	87.0
7.0	5.85	0.989	25.1	22.6	87.1
9.0	6.55	0.792	24.3	22.0	81.1
9.0	6.50	1.61	50.0	50.5	81.3
11.0	7.05	0.812	29.4	26.6	81.5
11.0	6.90	0.468	16.9	15.2	81.6
13.0	7.70	0.588	26.6	24.0	76.9
13.0	7.50	0.612	27.6	24.8	77.1

It is evident from these results that sulfurous acid is easily oxidized on platinum anodes to sulfuric acid of any concentration below 95 per cent. The concentration of the sulfuric acid has a great effect on the current efficiency. The current density also has a decided effect on the efficiency, but to a less degree than

RUN No. 6. 90 PER CENT H₂SO₄. BAROMETER, 750 MM. TEMP., 23.0 C.

Current	Voltage	Coulometer Weight Cu.	VOLUME OF OXYGEN		Current Efficiency
			Obs.	Corr.	
5.0	6.60	0.817	31.9	28.6	80.2
5.0	6.00	0.799	31.3	28.1	80.1
7.0	7.10	0.642	28.4	25.5	77.5
7.0	6.90	0.905	39.9	35.8	78.8
9.0	7.60	0.738	37.4	34.6	73.4
9.0	7.45	0.678	34.2	30.6	75.2
11.0	8.50	0.773	44.7	40.1	70.5
11.0	8.50	0.681	39.4	35.3	70.6
13.0	9.40	0.771	52.8	47.4	65.1
13.0	9.55	0.749	51.5	46.2	65.0

RUN No. 7. 95 PER CENT H₂SO₄. BAROMETER, 762 MM. TEMP., 22.0 C.

Current	Voltage	Coulometer Weight Cu.	VOLUME OF OXYGEN		Current Efficiency
			Obs.	Corr.	
5.0	7.45	0.977	56.8	51.2	70.3
5.0	7.10	0.879	51.1	46.0	70.4
7.0	8.05	0.701	44.4	40.0	67.6
7.0	8.10	0.869	56.0	50.5	67.1
9.0	8.90	0.751	52.2	47.0	64.4
9.0	9.15	0.750	50.5	45.5	65.5
11.0	9.80	0.622	50.6	45.6	58.3
11.0	10.05	0.692	56.8	51.1	58.1
13.0	11.60	0.786	72.5	65.4	52.7
13.0	12.00	0.673	61.1	55.1	53.6

RUN No. 8. 98.7 PER CENT H₂SO₄. BAROMETER, 762 MM. TEMP., 22.0 C.

Current	Voltage	Coulometer Weight Cu.	VOLUME OF OXYGEN		Current Efficiency
			Obs.	Corr.	
5.0	9.05	0.720	93.8	84.5	33.3
5.0	9.10	0.717	92.6	83.5	33.9
7.0	11.25	0.406	59.3	53.4	25.3
7.0	11.20	0.734	107.2	96.7	25.2
9.0	14.15	0.418	69.2	62.3	15.2
9.0	14.25	0.751	125.2	112.9	14.6
11.0	19.40	0.401	75.8	68.3	3.9
11.0	20.10	0.691	131.1	118.1	3.0

SUMMARY OF CURRENT EFFICIENCIES FOR THE DIFFERENT CURRENT DENSITIES AND ACID CONCENTRATIONS

Current Density Amp. per Sq. Dm.	PER CENT SULFURIC ACID							
	10	30	50	70	80	90	95	98.7
19	100	99.5	96.5	92.3	88.5	80.2	70.3	33.6
27	100	98.0	95.5	91.0	87.1	78.2	67.4	25.3
35	100	98.2	94.5	89.1	84.2	74.3	65.1	14.9
43	99.7	93.5	87.1	81.6	70.6	58.2	3.5	...
50	99.6	97.0	92.6	83.9	77.0	65.1	53.2	...

the concentration of the acid. The efficiency falls with increased current density. This is what might be expected from analogy with other cases. For example, the cathodic reduction of hypochlorite is diminished by increasing the current density.

Summary: The current efficiencies of the electrolytic oxidation of sulfurous acid in sulfuric acid of concentrations from 10 to 98.5 per cent with current densities from 19 to 50 amperes per square decimeter were measured. A platinum anode and a nickel cathode were used, separated by a clay diaphragm. The results show that this oxidation takes place with high current efficiencies even in strong sulfuric acid solu-

tions. For a given sulfuric acid concentration the current efficiency decreases with increasing current density.

Massachusetts Institute of Technology,
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The Selection of Centrifugal Pumps*

By D. McEoelid

In the commercial offices of firms manufacturing such articles as centrifugal pumps, the design of which requires technical ability of rather more than average quality, it is desirable that the methods of dealing with clients' inquiries be accurate, as flexible as possible, and easily checked. In many cases the selection has to be made from a tabulation of previously calculated outputs, necessitating, for the use of the commercial staff, approximate methods of interpolation when non-listed outputs are required. These are not, in general, accurate for wide variations from the list, and unless used with discretion are liable to result in serious errors. Output curves of the performance of each standard size of pump for various speeds are sometimes employed. Selection by means of these is slow and laborious, and the process necessitates the provision of a large number of curves. In order to assist engineers whose commercial pursuits do not as a rule permit of the leisure which would enable them to make themselves fully acquainted with all the subtleties of the centrifugal pump, it is well to have available an easily operated and sufficiently accurate procedure. Methods which enable a selling staff to decide, on short notice, which machine will best fulfil certain required conditions, without having to refer to the designers, have their double value in the saving of the time of the latter and in the impressing of the client.

It is customary for manufacturers of centrifugal pumps so to design them that they can be utilized for as great a variety of heads, speeds and quantities as possible. The evolution of a complete range of pumps generally results in the development of a series of groups, each group consisting of a number of pumps with gradually-increasing diameters of impeller, and with a definite ratio of impeller width to diameter and other dimensions in proportion, so that the pumps of a group are symmetrical. Thus arranged, almost any conceivable output can be provided for by selecting that type of pump and diameter of impeller most suited to the form of drive proposed and the general requirements of the installation.

The method described below has been developed to suit such standardized lines of pumps, and in addition

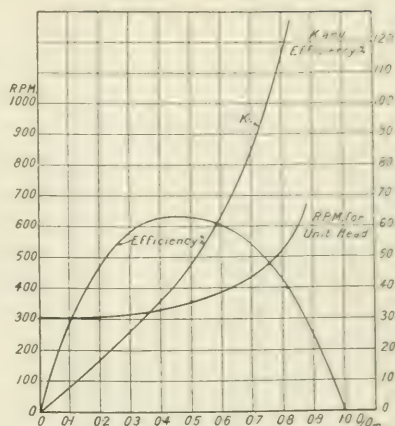


FIG. 2—VALUES OF EFFICIENCY K. AND R.P.M.

to overcoming most of the difficulties usually met with, provides also in a convenient form the complete characteristic of the pump. It will simplify the description to take the performance of an actual pump—Table I—and to employ the following notation:

TABLE I

Q, Litres Sec	h, Metres	Watts, Input	Efficiency, Per Cent	R P M
0	30.6	3350	0	1680
7.56	29.6	3120	42.8	1680
15.1	26.8	6520	61.0	1680
22.7	21.8	7750	62.5	1680
26.0	19.2	8010	60.1	1680
30.2	15.1	8280	54.0	1680
35.0	10.3	8420	42.5	1680
37.8	7.0	8400	31.0	1680
43.5 (max)	0	7810	0.0	1680

n = revolutions per minute.

Q = quantity of water, litres per second.

h = external head of the pump, metres.

D = diameter of the impeller, metres.

v = peripheral speed, metres per second.

The two following relations are true for a given pump, within reasonable limits, where A and B are constants, depending on the type and the position on the h - Q characteristic:

$$h = A \cdot n^2.$$

$$Q = B \cdot n.$$

It is also a property of similarly proportioned pumps, when operated at the same peripheral speed of impeller, that at corresponding points on their pressure-quantity characteristics the following relation holds:

$$Q/D^3 = \text{constant}.$$

The external heads which would be produced by such pumps under these conditions are equal. If, then, for a given pump the characteristic curves at constant speed be those shown in Fig. 1—the figures for which are given in Table I—and if Q_m be the maximum discharge the pump is capable of at that speed, the discharge for various conditions of head may be represented as a proportion of Q_m . The abscissæ then become $Q/Q_m = 0.1, 0.2$, etc. For each value of Q/Q_m the revolutions per minute n , at which one metre—unit—head can be obtained is calculated from the relation $h = A \cdot n^2$. In addition the actual values of Q are reduced to those which would be obtained at these speeds—and at unit head—from the relation $Q = B \cdot n$. From

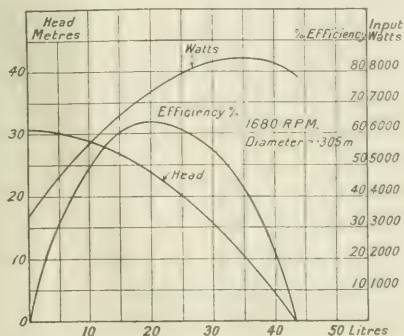


FIG. 1—CHARACTERISTIC CURVES AT CONSTANT SPEED

*From *The Engineer* (London), Oct. 13, 1916.

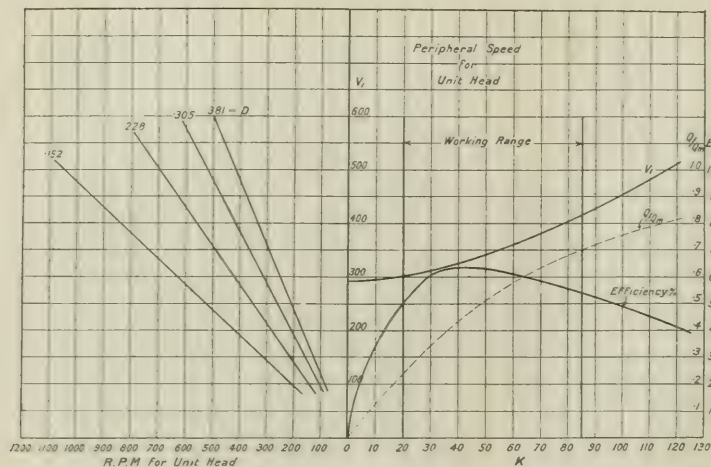


FIG. 3—PERIPHERAL SPEED FOR UNIT HEAD

these new values of Q at the reduced speeds, the values of $Q_1/D^2 = K$ are then calculated. The values of Q/Q_m , revolutions per minute and K are shown on Table II and plotted on Fig. 2. The latter gives the characteristics in another form and for the specific diameter of pump presents all the information necessary to obtain the performance curve at any speed. In order to make this information available for any pump of symmetrical design, it is necessary to introduce the peripheral speed

TABLE II

Q/Q_m	R.P.M. for Unit Head	Q_1 at Speed for Unit Head	$K = \frac{Q_1}{D^2}$	Efficiency, Per Cent
0	304	291	0	0
.174	309	296	1.39	14.95
.348	324	310	2.91	30.3
.522	360	345	4.87	52.0
.6	383	367	5.93	63.9
.664	432	414	7.78	83.5
.805	524	502.5	10.9	117.0
.87	635	609	14.3	153.5
1.0				0.0

Form 1

Quantity	Head
Output required	20
Output reduced to unit head.	$4 \frac{1}{2} = Q_1$
	23.8

Form B

D., Metres	K for Std. D.	Q/Q_m	Efficiency, Per Cent	Q_1 Metres/Min.	R.P.M. for Unit Head
.152	178	Outside the working limits			
.228	29	.675	55.8	402	362
.305	44.2	.47	43.5	332	345
.381	28.3	.322	59.2	309	259

Form C

D	R.P.M. $= \frac{Q_1}{D^2} \times K$	Head	Q	Watts $= h \times Q \times 0.81 \text{ eff.}$	Allowances	H.P.
.152						
.228	2750	23.8	2.1	8,690		
.305	1980	23.8	20	7350		
.381	1260	23.8	20	7860		

at which one metre head is developed, this being easily calculable from the known diameter of the pump in question and the speed shown on Fig. 2.

The resulting curves are plotted on Fig. 3, introducing at the same time, for assumed standard diameters, the revolutions per minute necessary to produce unit head. The selection by means of these curves is made in the following manner, calculation sheets being used of the form suggested:

Form A.—From the specified head and volume, the revolutions per minute not being specified, the output at unit head, Q_1 , is calculated from the

$$\text{following relation } Q = \frac{1}{Q} \sqrt{h}.$$

Form B.—From the standard curves, using the formula $K = Q_1/D^2$, the value of K is found for various standard diameters. (This is conveniently done by means of the slide rule.)

Only those values of K are taken which from an inspection of the curves result in a reasonable efficiency value. The values of Q/Q_m , efficiency and peripheral speed are taken from the curves and tabulated—Form C. The revolutions per minute and power required are then very simply calculated, and additions having been made for friction losses, the most suitable pump is selected.

In the case shown, for continuous running, the third pump is obviously to be chosen. For occasional work, where efficiency is not an important matter in relation to first cost the second pump, particularly for electrical drive, would be selected. A smaller motor would be required as well as the smaller pump.

For other cases—as, for instance, alternating current motor direct-coupled drive—the speeds available are limited, and for such cases this method enables one rapidly to select the pump which for such limitations, will give the best results.

Other uses of the standard curves will present themselves; e.g., the comparison of the performance of various types of pump in which the particular qualities of each are made prominent, the calculation of outputs for varying conditions of heads or speeds.

New Electric Steel Furnace in Sheffield.—A new type of electric steel furnace, known as the Greaves-Etchells furnace, is being built by Messrs. T. H. Watson & Co. of Sheffield, England. It is suitable for making all grades of alloy steels and high-speed tool steels in small ingots. The furnace is a three-phase furnace in which two of the carbons are introduced at the top and the whole of the hearth is connected to the third phase, acting as the third electrode. With a small furnace designed to melt 6 cwts. in three hours, it has been found possible to obtain five heats of 18 per cent high-speed steel in ten hours. The longest time occupied from charging to finished ingots was 1 h. 40 min. and the shortest time 1 hr. 15 min. This small furnace has already made over 560 consecutive heats of high-speed steel and the lining has once been renewed. The standard size in which this type of furnace is being built by Messrs. T. H. Watson & Co. is for a capacity of 10/12½ cwts., but some furnaces are also being built for larger sizes, up to 6 tons.

Rubber Sponge

By Andrew H. King

Rubber sponges have been in use for quite a number of years, but until recently no one has attempted to utilize their rather peculiar properties in any other way than as a substitute for the natural sponge.

There are many methods of preparation. The time-honored practice has been to mix with the batch some material such as ammonium carbonate, which at the temperature of vulcanization gives off considerable volume of gas, and thus causes porosity. Many different compounds have been used. Of those commonly known, two may be mentioned: U. S. Patent No. 1,103,359, July 14, 1914, to J. Huebner is for a sponge mixture consisting of 60 per cent rubber, 5 per cent rosin oil, 10 per cent zinc oxide, 10 per cent turpentine, 5 per cent sulphur, and 10 per cent ammonium carbonate. In Europe amyl-acetate finds considerable favor. A certain German sponge is said to be prepared from the following formula: 70 per cent rubber, 7 per cent sulphur, 5 per cent vermilion, 7 per cent zinc oxide, 1 per cent ceresine, and 10 per cent amyl-acetate. The actual manufacture of sponges or other articles of this material is a simple factory operation, and involves no greater difficulties than are present in every-day mold room practice.

A more modern process is that covered by German Patent No. 249,777, granted to F. Pfeumer. According to this method a soft rubber compound is cured in a mold under high pressure, using 200 to 800 atmospheres of an inert gas. This pressure is used only for the first few minutes of the cure. When it is released, the rubber is swelled to many times its normal volume, due to the contained gas. In this condition the cure is finished. The increase in volume is often as much as eighteen times normal. Because of certain mechanical difficulties, it is not possible to prepare objects of unlimited size. The inventor mentions that he has prepared cylinders up to 8 in. in diameter, and slabs 100 ft. long by 10 ft. wide by 2/10 in. thickness, by this process.

The Pfeumer method necessitates the use of very high pressures, which are always dangerous. G. Staunton, U. S. Patent No. 1,115,031, Oct. 27, 1915, uses just the opposite. He prepares a cement or dough of rubber, and subjects it to a partial vacuum, thus rendering it cellular. Vulcanization is effected by means of sulphur chloride in carbon bisulfide solution. When completely cured his product is washed with ammonia, so as to neutralize any acid.

Still another method, which seems to have great possibilities and will, no doubt, produce a grade of sponge low enough in cost to be available for many of the purposes for which pneumatic appliances are now used, is that of Schidrowitz and Goldsborough, British Patent No. 1,111, Jan. 15, 1914. The inventors operate directly on rubber latex, coagulating under conditions which yield a porous or cellular coagulum. These pores are fixed by vulcanization. The vulcanizing agent may be added prior to, during, or after coagulation, depending upon the type of article being made, and also upon the method of cure. Moreover, the vulcanization may be carried out in the wet state, and the coagulum may be such that the heat of vulcanization will bring about coagulation. In this case the sponginess is produced during the cure. It is well to mention that the coagulum need not be purified, and may be produced by use of heat, or any other common manner, as for instance: Acetic acid, organic acids which are comparatively insoluble in cold water or latex but which dissolve on heating, acid salts, carbon bisulfide, benzole, acetone, alcohol, and salicylic acid. For the production of porosity sub-

stances which generate gases when heated or by chemical action, such as carbonates, sulfides, etc., are added before, during, or after coagulation, depending upon the product desired. Vulcanization may be effected by sulfur, as such or in solution, or by compounds which liberate it. Steam is used for heating purposes.

Because of its cellular structure rubber sponge has several very peculiar properties. For example: it has the lowest apparent specific gravity of all solid bodies, being around 0.05. In spite of its cellular structure it is water tight, and very nearly gas tight. While it is honeycombed with minute cells, each cell is an individual unit and the rate of diffusion of gases through it is comparatively low. Because of its low specific gravity it has a very low specific volume, which thus brings its cost within range for common purposes. Perhaps one of the most important uses to which it has been put is in the preparation of life preservers. It will not water-log, is light, conforms easily to the lines of the body, and is not to be ruined by a pin prick. A life raft made with rubber sponge is as near fool-proof as one can be. All sorts of floating devices, such as buoys, markers, etc., may be improved by its use.

For some time the brains and time of many men have been occupied in a search for a substitute or modification of the pneumatic tire for automobiles. We have seen about everything from metal springs to tires made with the regular tire casing but containing a solid block of gum used as a bumper. The season of tire fillers occupies now only a page in the history of this search. Springs have been discarded because of their slowness to respond, and it has been decided by the great majority of automobile owners that nothing rides as easy as air, and rather than use tire fillers they would substitute solid tires and have it done with.

Two serious objections to most tire fillers are that under constant running they tend to heat up, and finally to decompose, and second, there is quite a tendency to form flat spots.

As has been mentioned, the most satisfactory tire filler to date is air. This air is customarily held in an inner tube under moderate pressure. It is now proposed to use rubber sponge molded to fit the inside of the tire casing, and in this manner produce a puncture-proof tire. The car still rides on air, but this air is confined in innumerable little sacks. The conditions necessary for a satisfactory tire filler are as follows:

1. It must be quite stable and so constructed that fatigue is reduced to a minimum.
 2. It must be light.
 3. The driving power must be transmitted elastically. Rubber sponge fulfills all these conditions. Recently Palmer tires filled with this material were driven 1950 miles with an average speed of 35 miles per hour without any apparent deterioration of the filling material.
- As would be expected, the cellular nature of sponge gives it great insulating properties, both in respect to heat and sound. It is proposed to use the material for the construction of sound-proof rooms, telephone booths, under musical instruments, and under vibrating and hammering machines, etc. It is proposed also for clothing for aeronauts and Arctic explorers.

So far we have spoken only of soft rubber sponge. Hard rubber sponge is also available. It is prepared from soft rubber sponge by further vulcanization. It is understood that the soft sponge is secured by properly regulating the time and temperature of the cure. The stock is made up with sufficient sulfur to effect the transformation to ebonite, so that after producing soft rubber further vulcanization takes it over to hard sponge.

This material has an apparent specific gravity of 0.2

to 0.065, which is $\frac{1}{2}$ to $\frac{1}{6}$ that of cork, and $\frac{1}{4}$ to $\frac{1}{12}$ that of wood. It may be worked in any way customary with hard rubber, such as sawing, boring, machining, etc. It still has the cellular structure of soft sponge, and therefore its insulating properties are not in the least effected. However, it is now not so susceptible to temperature change, and will stand temperatures up to 130 deg. C. It is recommended for ice-box walls, covering for flasks, and other insulation problems. Because of its low gravity, it has been recommended for battery jars to replace the common hard rubber jars now in use. This gives a cheaper jar, and one every bit as durable.

Hard sponge has considerable strength, and has been proposed as a material for the framework of aeroplanes. It has also been recommended as a material for constructing automobile bodies.

The Determination of Nickel in Iron Ores

By Philip Covitz

Although many investigators have studied and recommended the use of dimethyl glyoxime as a precipitant for nickel in solution by itself or with other metals, there appears to have been a decided lack of attention given to the details of all procedures in methods employing this reagent. In the hands of any but experienced chemists, unsatisfactory results have been frequent because of the failure to fully recognize and explain very important steps in the analytical process.

During a series of several hundred analyses for nickel in complex iron ores (Cuban ores containing Fe, Al, Cr, Mn, SiO_2 , S and P) at the Mining Department of the Massachusetts Institute of Technology, the writer has been able to develop a procedure which, if carefully followed, will give accurate and reasonably rapid results.

The procedure is as follows:

Dissolve 1 gram of finely ground ore (100-120 mesh) in 10 c.c. HNO_3 (1.42) and 10 c.c. HCl (1.2). The quantities may be varied (preferably using more HCl) according to the nature of the ore. Always use at least 5 c.c. HNO_3 , as this is essential to oxidize all reduced metals especially ferrous iron which will interfere later on. When the ore has gone into solution allow to cool somewhat and then add slowly (to avoid spattering) 10 c.c. H_2SO_4 (1.84). Boil on hot plate or over free flame cautiously until H_2SO_4 fumes come off freely. As the solution becomes concentrated, it will gradually turn green, basic sulphates will separate out as a white sludge and violent bumping and subsequent loss by spattering will result unless care is taken to control the heat. The H_2SO_4 is added to drive off the HNO_3 whose presence is injurious at a later stage in the process.

After the contents of the container have been brought to copious fuming, they should be cooled and then 30 c.c. water slowly added, agitating or stirring in the meanwhile. The addition of water to the concentrated H_2SO_4 in solution will cause considerable evolution of heat so that caution must be observed in such addition, else violent ebullition and ejection of contents may occur.

Add 2 or 3 c.c. HCl (to aid in solution of soluble salts) and heat 10 to 15 minutes on hot plate or until salts have dissolved. Put in 5 grams citric or tartaric acid (to prevent precipitation of trivalent metals), and when dissolved filter into a 300 c.c. beaker. The importance of driving off HNO_3 by the addition of H_2SO_4 will be recognized on adding the citric acid. If HNO_3 is present, it will react with the citric, decomposing the latter. This reaction will be indicated by the rapid evolution of the gas (probably CO_2) and will interfere with subsequent precipitation of nickel.

Wash the filter thoroughly with hot water and dilute the filtrate to 100-125 c.c.

Now carefully neutralize the filtrate by adding NH_4OH slowly, stirring thoroughly until a drop of solution just turns red litmus paper blue, then make faintly acid with HCl . This part of the procedure is very important and must be given special attention. As the NH_4OH is added, there will be a change from a pale green to a brownish color, which latter will suddenly change to dark green just before the neutral point is reached. This green should persist even past the neutral point. If a slight excess of NH_4OH beyond the neutral point produces a dark brown color, not enough citric acid has been used. In such a case slightly acidify the solution with HCl and add enough more citric acid to produce the desired green color, the lighter the green the better.

Having made the filtrate slightly acid, heat to 70-85 deg. C., add slowly and with constant stirring 20 c.c. of an alcoholic solution of dimethyl glyoxime (which has been prepared by dissolving 8 grams dimethyl glyoxime in 1 liter of ethyl alcohol) and just enough NH_4OH to form a precipitate. A very convenient stirring rod may be made by using a thermometer, protecting the mercury bulb by a small band of rubber tubing about $\frac{1}{2}$ in wide, placed on the very tip end. This serves as a combination stirring rod and thermometer.

Care must be taken to avoid an excess of NH_4OH , as this tends to prevent the formation of the nickel precipitate.

Heat the solution until the alcohol begins to boil off. Remove from hot plate and allow to stand a minute or so when the precipitate will coagulate readily. Filter on a weighed Gooch crucible, wash with hot water and dry at 110 deg. C. for forty-five minutes. Weigh and multiply by 20.31 to get the percentage of nickel in the sample.

The precipitate should be red and crystalline, while the filtrate should be amber yellow to yellowish green and clear.

If a large excess of NH_4OH has been added, the filtrate will be dark, sometimes brown, and not transparent. In such a case the excess of NH_4OH has probably caused a precipitation of ferric hydroxide. This will, of course, give high results due to filtering off of ferric hydroxide along with the nickel precipitate. The latter will be brownish in color and should be discarded. If directions are followed, however, this will not occur.

There have been times when the writer was troubled with a blood red filtrate from the nickel precipitate. This was shown to be due to the presence of ferrous iron. The red color indicates dissolved nickel. If such a condition occurs it shows that not enough HNO_3 has been used, and that oxidation of oxidizable matter has been incomplete. This may be remedied by slightly acidifying the filtrate from nickel precipitate, boiling with 10 c.c. of bromine water and precipitating formerly dissolved nickel by addition of NH_4OH in very slight excess, filtering and adding the precipitate to that first obtained.

The method in brief then is: Dissolve 1 gram of ore in 10 c.c. HCl (1.2) + 10 c.c. HNO_3 (1.42). Cool, add 10 c.c. H_2SO_4 (1.84) and evaporate carefully until H_2SO_4 fumes copiously. Cool, then add cautiously 30 c.c. water, agitating meanwhile. Add 2 to 3 c.c. HCl , heat ten to fifteen minutes, and filter into 300 c.c. beaker. Dilute filtrate to 125 c.c., neutralize with NH_4OH . If on passing the neutral point the color of the solution is brown, add enough citric acid to bring to desired green. Add few drops HCl (enough to make barely acid). Heat to 70-85 deg. C., add 20 c.c. glyoxime solution, stirring constantly, and allow solution to come to boil. Let stand for minute or two, filter on weighed gooch, and dry in oven at 110 deg. C. for forty-five minutes, cool and weigh.

20.31 per cent of precipitate is nickel.

The precipitate may be removed by use of hot HCl or HNO_3 , in which it is soluble.

Since the completion of the writer's work there has appeared in the September number of the *Journal of Industrial and Engineering Chemistry* an article by G. L. Kelley and J. B. Conant of the research department of the Midvale Steel Company of Philadelphia, on the "Use of Diphenyl Glyoxime as an Indicator in the Volumetric Determination of Nickel by Frevert's Method." This article is interesting because of the fact that nickel is first removed from solution by precipitation with dimethyl glyoxime, the precipitate dissolved in acid and then the nickel determined volumetrically. Kelley and Conant, however, recommend the use of an ammoniacal solution of glyoxime instead of the alcoholic solution used by the writer, and also precipitation of the nickel in an ice cooled solution.

In view of the fact that excess of NH_4OH is detrimental to the accuracy of the process, it would appear that the use of the ammoniacal solution of glyoxime would be highly undesirable because of the great danger of introducing an excess of NH_4OH by its use. Again the precipitation of nickel dimethyl glyoxime in the cold is quite unsatisfactory, for not only is the precipitation very slow (Kelley and Conant advise one hour's standing), but the precipitate itself is not as crystalline or easy to filter as is the case when higher temperatures are the rule. The formation of a precipitate at 70 deg. or over is almost instantaneous.

To sum up then, the determination of nickel by the method given is accurate, reasonably rapid and will give good results even in the hands of an inexperienced analyst. It has the further advantage of obviating the necessity of removing other elements, citric acid serving to take care of iron and other metals present. The writer feels that while the volumetric method of H. L. Frevert (Blair's Chemical Analysis of Iron, 7th Ed., 1912) may be more rapid, it is not as accurate or as satisfactory, and certainly in the hands of the average analyst not as simple of operation and as productive of results as is the gravimetric method herein described.

Massachusetts Institute of Technology.

The Chemical and Physical Properties of Foundry Irons

By J. E. Johnson, Jr.

(Concluded from page 646)

Principal Varieties of Foundry Irons and Their Composition

Foundry irons may be divided according to the kind of castings made into four classes, as follows:

Machinery and general castings, chilled castings, malleable castings and heat-resisting castings, especially ingot molds.

Machinery and General Castings

The range of these is very wide and the specifications for the iron used in making them vary accordingly. It is only possible to cover the subject in a broad general way.

SILICON

The silicon in machinery castings may be said to vary from $1\frac{1}{4}$ or $1\frac{1}{2}$ per cent in large heavy castings up to 3 or $3\frac{1}{4}$ per cent in very small light castings.

SULPHUR

Sulphur in iron machinery and general castings is almost always an unmitigated evil. It is sometimes

used to close up the grain of the iron, but this causes a simultaneous hardening of the surface of the casting, particularly sharp corners and edges, which are quickly chilled. This greatly increases the difficulty of machining such castings, and the use of sulphur for this purpose is never justifiable.

Sulphur is always added to the iron when it is remelted in a cupola for casting, the amount so added varying from 0.03 per cent in the best cupola practice up to 0.10 per cent or even more in the worst and averaging around 0.05 per cent in ordinary good practice. As the sulphur in good castings should be below 0.08, or certainly below 0.09 per cent, it is evident that the sulphur in the iron must be kept under 0.05, and preferably under 0.04 per cent, and these are the ordinary specifications for foundry iron.

PHOSPHORUS

Phosphorus was formerly considered to be a detriment to foundry castings and it was considered desirable to keep it as low as possible, or at least below 0.3 per cent, but we know now that phosphorus imparts fluidity to the metal and also increases the strength up to certain limits so that in machinery castings phosphorus commonly runs from 0.04 to 0.75 per cent. In some specially thin castings, such as stove plate, it runs higher even—up to 1 per cent in order to obtain the fluidity necessary to pour these thin shapes, while in automobile cylinders, as noted earlier, it is necessary to keep the phosphorus under 0.3 per cent in order to prevent spongy spots in the castings. In the ordinary run of machinery castings, however, the phosphorus ranges within the limits given.

MANGANESE

Manganese specifications for foundry iron vary between extreme limits. In some cases as much as 2 per cent is desired for special reasons, while in other cases the least amount possible is desired, but these extreme specifications are for special cases and manganese in the iron for ordinary machinery and general castings runs from about 0.6 to 1.0 per cent.

CARBON

No attention is paid to the carbon in ordinary machinery castings except where special strength is desired and then the carbon is lowered by adding steel scrap to the cupola charge; this constitutes the so-called semi-steel.

OXYGEN (IN MACHINERY CASTINGS)

The relation shown in the previous chapter between oxygen content and strength of castings indicates clearly that when strong close grained and dense casting are desired, an iron high in oxygen should be used. When a mixture of irons is introduced into the cupola, it is easier to obtain the desired amount of oxygen in the cupola iron by the introduction of most of the oxygen with that portion of the mixture containing the least manganese primarily and the lowest silicon secondarily. As to the absolute quantities of oxygen desirable, we have not as yet sufficient information on which to base exact specifications. Iron with 0.06 oxygen is 50 to 75 per cent stronger than ordinary coke iron without oxygen, and this strength persists when the iron is remelted in the cupola. The kind of castings desired must control the relative importance to be given to oxygen and the other elements. As a general thing, the strength imparted by a given percentage of an oxygen bearing iron is more proportional to the percentage of that iron added.

Chilled Castings

SILICON

Silicon is the element which has the maximum effect in promoting the separation of the carbon from its original combined form into graphite, and as the production of chilled castings consists in keeping the carbon combined with the iron, the silicon must accordingly be low. For car wheels, the principal purpose for which chilled castings are used, the silicon is desired about 0.75 per cent. For other purposes, it falls as low as 0.25 per cent, and for still others rises as high as 1.25 per cent.

SULPHUR

For some kinds of chilled castings where great hardness without much strength is desired, iron with sulphur running up to 0.2 or even 0.3 per cent is sometimes used as an ingredient of the cupola charge, and in some car wheel foundries the regular practice is to make car wheels containing 0.18 or 0.19 per cent sulphur, but this is exceptional and in my judgment bad practice. The chill of the castings should be obtained by lowering the silicon rather than by raising the sulphur except within very moderate limits. In chilling irons made with coke, sulphur is commonly accepted up to about 0.1 per cent.

PHOSPHORUS

Phosphorus in chilled material commonly varies between 0.25 and 0.7 per cent. The phosphorus in the iron for this material ordinarily lies within the same limits. For car wheel purposes phosphorus is not desired above 0.35 per cent.

MANGANESE

Extraordinary latitude is used in manganese specifications for chilled materials. Some consumers want the manganese down to a trace while others specify manganese up to 2 per cent. The reason for this appeared earlier and need not be repeated here. In the ordinary run of chilled castings, manganese ranges between 0.4 and 0.8 per cent.

OXYGEN

In the foregoing chapter it has been shown that oxygen exercises a greater influence on the chilling power of an iron than any other element except silicon. When chilled castings are to be made, it is not desirable to obtain the chill desired by lowering the silicon or raising the sulphur beyond certain limits because of the brittle crystalline chill which these extremes cause. By the presence of oxygen in the iron, we can obtain the desired amount of chill without a very low silicon and in the almost complete absence of sulphur.

Sulphur is the element which causes the greatest degree of brittleness in chilled castings, especially car wheels, and its detrimental effects must be reduced by increasing the manganese which in turn has a very undesirable effect on the properties of the chill. For this reason the best chilled castings will come in time to be made of irons low in sulphur with a moderate amount of silicon, high in oxygen and low in manganese.

CARBON

It is in the field of chilled castings that the most attention is paid to the quantity of carbon present in the iron. The reasons for this are numerous and complicated as have appeared earlier, so they do not need to be given here.

Suffice it to say that for some chilled castings the carbon is desired well below 3 per cent, while for many other purposes chilled castings have proven of inferior quality because they did not contain a sufficient amount

of carbon to give them the hardness desired. It is probable that the maximum amount which can be used satisfactorily is about 4 per cent.

When the carbon rises much above this point, another set of influences come into play which are likely to destroy rather than to augment the hardening action. In chilled rolls much lower carbon is required, but this, as explained in connection with hyper-eutectic irons, is obtained by mixing steel scrap with the charge or by oxidizing part of the carbon in the air furnace.

Malleable Castings

Malleable castings in American parlance are castings which are solid white when cast and then have their carbon converted into graphite by annealing at a high temperature. Such castings can be bent cold and have a considerable amount of toughness. When subjected to a tension test they show a decided elongation and reduction of area which are not shown at all by ordinary casting iron, hence the name malleable castings.

In order to meet the condition that the castings must be white when made, the silicon must be kept comparatively low, ranging from about 1 per cent for large, heavy castings to about 1.75 per cent with small castings of light section. More or less of this is oxidized out in the air furnace, in which the iron for these castings is generally melted.

SULPHUR

Sulphur is very objectionable in the malleable process because it tends to prevent the breaking down of the carbon into graphite, which is the essence of the process. Iron for malleable castings is generally melted. The absorption of sulphur in the air furnace is very much lower than in a cupola, but in spite of this the sulphur specifications for iron for malleable castings are as severe as those for ordinary foundry iron, sometimes even more so. For most purposes the sulphur is held below 0.05 per cent and it is usually desired below 0.04 per cent.

PHOSPHORUS

The specifications for this element are much closer in the case of malleable castings than in most others. If the phosphorus be too low, the metal has not sufficient fluidity, and if it be too high, the metal is brittle and unreliable when annealed. The phosphorus is, therefore, very generally kept between 0.12 and 0.25 per cent.

MANGANESE

The practice in regard to manganese varies in this department of the industry almost as much as in chilling irons, some manufacturers desiring it high and others low. The probabilities are that manganese should be between 0.3 and 0.6 per cent for best results.

CARBON

The conditions in regard to carbon are very much the same in malleable castings as they are in chilled castings, although the limits through which it is made to vary are not so wide. Some manufacturers will pay a premium for iron with carbon well under 3 per cent, while others accept the carbon as it comes from the furnace without comment. It is my impression that no commercial iron ever contains as little as 3 per cent carbon when it comes from the blast furnace, and this element can only be reduced to these low limits by treatment outside the furnace.

OXYGEN

It has been definitely ascertained that the presence of oxygen is highly beneficial in chilled rolls melted in the air furnace. The practice in this branch of industry is very similar to that in the malleable industry, and taken

in conjunction with the fact that the best malleable is made with charcoal iron, it is probable that oxygen is highly desirable in malleable castings. The fact that its presence tends to throw the carbon into the combined condition in the presence of even considerable percentages of silicon, indicates also that the presence of oxygen is desirable in this branch of the foundry industry.

Ingot Moulds and Heat Resisting Castings

In order to resist the expansion and contraction strains brought about by the frequent changes of temperature, iron must have a loose and open structure. The graphite must be in large flakes so that the individual grains of iron can hinge on one another, sliding and bending on the soft graphite. Anything which tends to close up the grain of the iron and reduce the area of the graphite flakes by coagulating them into nodular particles, reduces their ability to act as hinges, and therefore makes the iron more rigid. This means that being unable to bend under the stresses brought about by contraction and expansion, when exposed alternately to heat and cold it soon breaks. Our object, therefore, must be to produce the most graphitic iron.

SILICON

For reasons which were explained at least in part earlier, the maximum amount of carbon is taken up by iron containing about 1 to 1½ per cent silicon. Therefore, the silicon in ingot molds is always kept within these limits.

PHOSPHORUS

Experience has proven that phosphorus exercises a vital influence on the life of ingot molds. Molds made from iron containing more than 0.08 per cent phosphorus (the Bessemer limit) fall off rapidly in the number of heats they give in service. The reason for this is not fully understood, but it is probably due to the effect of phosphorus in hardening the iron and closing up its grain, as described earlier. For this reason the phosphorus specifications for ingot molds are very severe and it is in all cases kept as low as commercial considerations will permit, always within the Bessemer limit.

MANGANESE

As was shown earlier, there is a certain quantity of manganese which makes the softest iron. An amount either smaller or larger than this will make the iron harder. This amount is roughly from 0.4 to 0.8 per cent, and it is within these limits that the manganese in ingot molds should be kept. If it rises, the silicon must be raised to offset its hardening influence on the iron.

SULPHUR

In order to have the iron as soft and graphitic as possible, it is necessary that the sulphur be kept to the lowest possible limits, and this is always done in practice. Conditions in this respect are greatly bettered by the fact that ingot molds are usually cast from direct metal, that is, metal taken directly from the blast furnace, not cast and remelted as is done with practically all other kinds of castings. There is no doubt the lower the sulphur is kept the better, and it should be always under 0.05 per cent to secure the best results.

CARBON

The carbon in the ingot molds should be as high as possible to promote the greatest possible formation of graphite in accordance with the laws controlling its action already explained. This, however, is a matter whose control is subordinate to that of the other elements, and is accordingly ignored in practice.

OXYGEN

Recent investigations have proven that this element exercises the most powerful influence of any, except, perhaps, silicon, upon the life of ingot molds. It has been shown how powerful is its influence in coagulating the graphite, and it has been found in practice that ingot molds made from iron relatively high in oxygen give only a fraction of the life of those made from an iron of identical analysis except low in oxygen. This is not generally known, but has been proven in practice in the most indisputable way. For this reason, the quantity of oxygen in the iron should be a primary consideration, and to reduce this it may even be justifiable to raise the manganese. If the oxygen cannot be reduced in the furnace to sufficiently low limits, it should receive a treatment outside the furnace in order to bring about this result.

Grading in the Cement, Coal and Cork Industries

By Edward S. Wiard

Cement

For the manufacture of this material a mixture of an aluminous and limy nature is needed. In the Lehigh district these exist side by side. In some properties in this district the proportion of shale and limestone occurs almost in the proper proportion and correction of the mixture of the two constituents is called for rather than proportioning (Fig. 1). After proportioning, the con-

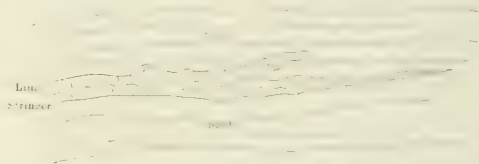


FIG. 1—SHALE AND LIMESTONE DEPOSIT.

stituents of the cement are burned almost universally in long revolving calciners heated by a coal dust flame. The resulting clinker is reduced by rolls and mills, the Griffin type being popular, and following this the final reduction is made in tube mills on leaving which machine 80 to 85 per cent of the cement will pass a 200 mesh screen.

At the eastern plants cement has been sold as low as \$0.65 per bbl., the cost of production ranging from \$0.40 to \$0.55. The production of Portland cement in the United States has risen from nothing in 1890 to over 25,000,000 bbl. at the present day, of which the Lehigh district produces in the neighborhood of 30 per cent. The average price for the whole country has fallen from \$3.00 a bbl. in 1890 at the works to about \$1.00 a bbl. at the present. In the western states the price is as high as \$1.50 per bbl. at the works.

Cementitious quality resides entirely in the finer particles of the cement. A good Portland cement should show at least 92 per cent through a 100 mesh sieve and 75 per cent through a 200 mesh sieve. This test is, however, merely a relative measure, for of two cements complying with it one might be superior to the other through having a much greater amount of very fine material. If a closed circuit were established below the tube mill, all material over a certain size being returned to the tube mill, the ensuing product would undoubtedly be more valuable, but it is a question whether, with fixed test conditions such as exist today, the superior cement, with its greater cost, would find a general sale. Again

the proper machine to effect the separation has not been devised, although the McKesson belt machine described in an earlier article of this series on the grading industries or something similar may be applicable.

There have been some tests performed to show the better cementitious quality of the finer part of cement, but they have not been conclusive, merely showing in a qualitative way that as the fineness is increased a better result is secured.

Coal

Anthracite coal is graded into the following sizes:

Size	Through	Over
Broken or grate.....	4-inch square	2 $\frac{1}{2}$ -inch square
Egg.....	2 $\frac{3}{4}$ -inch square	2-inch square
Stove.....	2-inch square	1 $\frac{1}{2}$ -inch square
Chestnut.....	1 $\frac{3}{4}$ -inch square	$\frac{3}{4}$ -inch square
Pea.....	$\frac{3}{4}$ -inch square	$\frac{1}{2}$ -inch square
Buckwheat No. 1.....	$\frac{1}{2}$ -inch square	$\frac{1}{4}$ -inch square
Buckwheat No. 2 or rice.....	$\frac{1}{4}$ -inch square	$\frac{1}{8}$ -inch square
Buckwheat No. 3 or barley.....	$\frac{1}{8}$ -inch square	1/16-inch round

The last three sizes are used for steam raising in competition with soft coal and are never sold for domestic purposes. The cost and difficulty of grading below $\frac{1}{8}$ inch and of separating the slate or other impurity from the coal is very great.

The very fine coal goes to the culm pile or returns to the mine for filling. There would be a large reward for inventors who were capable of treating economically this material and delivering it free from impurity and fines.

The number of sizes of coal made with soft coal varies according to locality. There is not much done in this respect. In the east soft coal is seldom graded, being used just as it is broken down and run out from the mine. In the west, where, except for the small patches of anthracite in Colorado and elsewhere, the coal is all soft, it is graded for domestic sizes, but this rarely extends to offering the purchaser more than run of mine lump or nut size. The lump being the nut and slack removed, the latter being sold separately.

Practically all types of screen are used in coal mining. Owing to the greater breakage, flat screens are preferred to revolving, but the latter are used to a great extent. Stationary and shaking grizzlies are the preferred flat screen. The Cox and shaking grizzly described under the technology of screening has an extensive use in the Pennsylvania field. The requirements for a coal screen are capacity, medium quality of work, and freedom from coal breakage.

In addition to the ordinary types of flat screens revolving disc screens are used and give positive advance and great freedom from breakage. Devices of this kind are, of course, only permissible for the coarse grades.

In addition to the ordinary inclined stationary grizzlies, consisting of bars held together with washers, various forms of screens with wavy surface are used, the effect of which is to stir up the mass being fed, and to give the undersizes a chance to get through the apertures. George W. Cross has had a multitude of patents bearing on screens of this character, for further information concerning which reference should be made to the patent files. For the fine sizes shaking screens are preferred.

In the anthracite and western washeries all the different types of screen are employed, and this applies to washeries treating the mine product as well as those re-treating culm banks.

The earliest mention of coal in the United States is recorded in the journal of Father Louis Hennepin under the date of 1679; he mentioned the site of a "cole" mine as on Illinois River, near the present city of Ottawa. In a report to the Virginia Assembly in 1701 mention is made of a discovery of coal in the Richmond Basin near Richmond, Virginia. The first mining of coal was from this locality between 1720 and 1750. Coal was discov-

ered in Ohio in 1755, but production did not begin on a commercial scale until 1838. Coal mining in the leading coal state of Pennsylvania began in the bituminous field in 1760, the first discovery being near Fort Pitt, or Pittsburgh. The first discovery of anthracite in Pennsylvania was in 1762. Commercial mining began near Pittston in 1775. It was not until nearly thirty years later that coal began to be mined in the Schuylkill district of the anthracite field. From 1807 to 1808 the shipments from the Wyoming district alone had reached a tonnage of 12,000 tons, and the anthracite coal business was well established. (For further historical notes see Mineral Resources of the United States, 1913.)

Cork

The cork tree is a species of oak (*Quercus Ilex*, better known as *Quercus Suber*), and the outer bark, which is the commercial cork or wood, is first harvested when the tree has a circumference of about 16 inches and thereafter regularly every nine or ten years throughout the life of the tree. The best bark commercially is obtained when the tree is over five years old. Stripping does not injure the tree and makes the formation of a new bark more rapid than that of its predecessor. The bark is cut from the tree by encircling cuts at top and bottom and these must be carefully made so as not to injure the tree. Following this a longitudinal cut is made and the bark pried off with wooden wedges. Bark can also be removed from the branches of the larger trees provided it is at least a half inch thick.

The bark from the trunk of the tree attains a thickness of 2 inches or more and the yield from a single tree at one cutting may be as high as 500 lb. or as low as 50 lb. After a few days drying following the stripping the bark is boiled to make it soft and flexible and to make easy the scraping off of the woody outer coating. It is then baled for shipment, after being graded for thickness and quality.

The part of the cork which faces the tree is called the belly and is reckoned as one-eighth inch thick. The outer layer also reckons as one-eighth inch thickness and is called the outside. The part between these two layers is called the thickness and ranges in depth from one-half to three or four inches.

All cork wood comes from Andalusia, in Spain, the principal shipping ports being Barcelona and Seville. Practically all the cork is exported, but of late years there has been some attempt to manufacture cork products in Spain.

Most of the bark is first cut up for stopples, which in times past used to be done by hand labor, and that method is still practised in Spain. By this method the cork boards had to be cut into strips, after sorting into a great number of grades according to thickness and quality. The width of any cork stopple is limited by the thickness of the cork, for the latter is cut into strips longitudinally and the stopples cut from the strips cannot attain a greater diameter than the thickness of the bark. Where cutting by hand is in practice the strips are cut up into squares and whittled to the proper shape and finished by sandpapering. By this method there is, of course, great waste, for the chips which result are not entirely suited to other uses for which granulated cork may be used. One by-product of the cork manufacturing industry in Spain is the cork powder in which grapes have been packed in the past. California grapes are now packed in redwood sawdust, which has been found to be an efficient substitute.

The whole range of manufactured cork products is produced in the United States. The procedure at one plant for producing stopples will serve for all. The bales are received from Spain containing slabs approximately 4 feet long and 18 inches wide. A bale weighs from

160 to 200 lb. The grade of the cork depends first on the thickness, as the thicker the cork the higher the price it commands. Second on the proportion of solid, smooth fiber, free from channels, cracks or other air passages. The cork costs on an average 12 cents a pound at New York and 12½ cents at Chicago (these are pre-war figures).

The slabs are first steamed and then cut up into long strips, as is done in the hand process. While still warm and plastic the strips are passed through a machine which punches out a single row of blanks. If the bark be unusually thick or the cork blanks small then two rows can be punched at one time. The blanks are then passed to a tapering machine. After this they are sand-papered and disinfected and are then ready for the market.

While the making of stopples is an important industry the bulk of the output of the factories has to do with cork products made from the waste of the cork strips.

In the manufacture of cork board and insulating material the waste from stopple factories on fresh cork board is ground up in revolving disintegrators. Following the disintegration it is screened on gyrating bolters and made into cork powders for heat insulation cork board or tread-cork inner soles for shoes, etc. Cork board is either put together with a tarry bond under heat and pressure or its own oils will furnish a bond under heat and pressure. The screen sizes made by the different manufacturers vary according to their personal notion as to what is proper in this respect and the varying demands of the trade. At one of the factories visited they were using the following sets of screen in the bolters: 3/8, 5/16, 1/4, 3/16, 1/8, 3/32, 1/16, 1/24, 32 mesh, 36 mesh. The undersize of the last screen has a use for linoleum making if sufficiently pure.

In the grinding of the cork the greater proportion of the woody outer layers which cannot be removed by scraping or which would entail too great a loss of good cork if cut away, grinds up more rapidly than the true cork, which is very resistant and forms shreds rather than granules, the woody portion consequently appears in larger proportion in the finer sizes.

This contaminated material is one of the problems of the graded cork industry. At one of the factories middlings purifiers such as are used in the flour mills are employed to effect a separation. When used for cork the latter is, of course, the product which is raised by the air current and carried to the separator. At another of the cork plants some tests were made with the Sutton-Steele table with quite a considerable degree of success.

Quite frequently the cork from the fine sizes is so impure that it must be thrown away. Revolving screens cannot be used for grading cork with any degree of success because of the buoyant effect of air currents which are set up by the motion of the screen. Reciprocating screens are not favored for the same reason, to a lesser degree and for the additional reason that the motion of such screens is too violent and keeps the mass of cork in too agitated a condition without sufficient contact with the screen.

Cork crushers are shredders and break up the cork by tearing it to pieces. Cork screening considered from the point of absolute size is very unsatisfactory, the cork shreds of any size comprising particles which may readily be compressed to a smaller compass or from which fragments of loosened cork may readily be detached.

The process of making linoleum was invented by Frederick Walton in England in 1860 and the product was first brought out under the name of Kamptulicon, but later received the name linoleum. The foundation

of linoleum is jute burlap. For manufacturing linoleum the very best grade of cork must be used and ground very fine in a buhr mill. As in flour milling, care must be taken that the dust arising from the grinding operation does not become so excessive as to cause liability to dust explosions.

The bonding material for the cork powder is what is known in the trade as cement. For this purpose linseed or other drying oils are used, these being oils which on exposure to the air will absorb sufficient oxygen to form a solid resinous mass. The linseed oil must be of good quality. The oil is first boiled, as in paint making, and the process of drying is facilitated by adding a small quantity of oxide of lead. From the boiling tanks the oil passes to pieces of light cotton fabric known as scrim, which hang vertically from iron bars. The oil is poured over the scrim and what adheres to the surface at a temperature of about 100° F becomes hardened. This operation is repeated from time to time until there is a coating on the scrim of sufficient thickness, when it is cut down and ground between rollers. The usual thickness of the skin on the scrim is one-half inch. The ground oil is then mixed with resin and kauri gum until the whole mass is homogeneous and forms the cement.

The cement and cork are then mixed together, and if the linoleum is to be plain the coloring matter is added at this stage. The mixture is then rolled onto the jute burlap backing, there being two cylinders to effect this operation and secure evenness of the layer. The printing of the design is done by machinery. Rising and falling color blocks are used, this motion aiding the repetition of the design. Each set of blocks have their own color and all the different colors have to be printed before the design is complete. The movement of the linoleum under the printing blocks is continuous.

In the manufacture of inlaid linoleum the mixture of cement and cork is compressed into sheets of different colors which are afterwards cut up into the components of the design and are affixed to the burlap by pressure. In another process the linoleum mixture in the form of a powder is dropped upon the jute in a way to make the design and is then subjected to heavy pressure to fix it and secure a permanent contact with the backing.

Science and Industry*

By J. Swinburne

A lecturer on this subject is expected to discuss the dependence of industry on mathematics, physics, chemistry, bacteriology, botany, and to a less extent a few other branches of science, such as biology, geology, and astronomy, and he is expected to show how the universities can help the industries of this country in two directions. The first is training men in the different branches of science, so that they can go into industrial work and be of the greatest value; the second is helping manufacturers directly by the advice of university professors and by carrying out technical research at college laboratories.

Coal mining involves some geological knowledge. Burning coal to get heat is applied chemistry. It is generally misapplied chemistry, because furnaces are usually not designed to give the mixed heated gases time to finish their reactions before the heat is taken from them. But, much more important than this, in burning raw coal we are wasting products which are daily becoming more valuable. The ordinary house fire, for example, is a barbarous apology for a heating device. Navigation depends on astronomy; metallurgy is a

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branch of applied chemistry; the design of good steam, gas and oil engines demands a competent knowledge of applied thermodynamics. All machinery embodies applied mechanics. In many cases, such as metallurgy, mechanics, the steam engine and the sailing ship, the application preceded the science; but in most modern developments, as, for instance, electrical engineering and fine chemicals, the industry has followed the science, helping in its turn, so that they continue to develop together.

Many branches of industry are the direct application of scientific knowledge or discovery, made without any idea of its practical value. The foundation principle of wireless telegraphy is a good example of this. Again, few students of Routh's rigid dynamics would have thought of making a gyrostad serve as a compass. Problems of capillarity seemed to have only scientific interest, yet Elmore's process for the separation of complex ores and its various modifications which have been worth hundreds of thousands to those concerned—except the inventor—depends on differences of surface tensions. In short, every industry in the country has its technology, or applied science, and the better this is understood by those in charge the better it is for the industry and for the country.

It is not my duty to discuss science as the root, or even a branch of education in itself. I am not an expert in education. I do not understand why education is as it is, or what it is meant to do. It seems to be like virtue, its own reward, without any ulterior advantage. To my non-expert mind, education ought to have four main objects. First, to enable one to earn his living, because if he cannot make his living nothing else is much use. Second, to let one know enough about his health to secure it. It is no use making a living or anything else if, owing to your own ignorance, your health is wrecked and you are prematurely buried. Third, to make one a good citizen. Fourth, to enable one to enjoy his well-earned leisure properly. These principles appear to be wrong, for they do not in the least fit education as commonly inflicted.

All the same, I will assume that under the first head there is a question of university teaching of science, with the object of its connection with industry. The main question is, then, How can universities best fit students to make their living by science in industry? To make the discussion complete, we ought also to discuss the question, How can business men make the best use of universities and of the men trained by them? This last question need not be discussed here, except in so far as the attitude of business men must react on universities attempting to work in conjunction with them.

In discussing its relation to industry, we must understand what we mean by science. Mathematics is the science of quantities and their relations. There are pure and applied mathematics. Pure mathematics is a study by itself. Kelvin called it the quintessence of common sense. The pure mathematician has one part of his brain very highly trained in one direction, and he has a remarkable mental acquirement and a special kind of knowledge and ability; but in a sense he is of no use, and pure mathematics is of no use. Mathematics may be applied to solve problems in astronomy, physics, mechanics, chemistry and statistics. To one devoted to pure mathematics this is a kind of debasement of his subject, and he is apt to look down upon people who use mathematics for such low purposes. The pure mathematician works strenuously, extending the bounds of his subject, and develops a new theorem or invents a new calculus. The astronomer or the physicist follows his work, and utilizes his advances to attack his own

problems by applying them. We thus have pure mathematics and applied mathematics. Sometimes the same man—Newton, for example—makes advances in both pure and applied mathematics.

In science generally we have the same distinction. Science itself is a complicated fabric of organized knowledge of Nature. The man of science devotes his life to extend this fabric of knowledge in new directions, and perhaps even more to elucidating the relations of the various elements, the object being to make the wonderful fabric complete in all its parts, with their interdependence, as far as it can be, clear to the limits of the mind. In a sense this is of no use; but surely it is the noblest exercise of the human intellect. This is called pure, as opposed to applied, science, because it has no direct ulterior purpose. The term is bad, as pure and applied are not opposed, and all kinds of science are quite pure. Theoretical has been proposed, but in the popular mind theoretical is opposed to practical, while to the technologist nothing is practical unless it is theoretically right. I will, therefore, use the word academic to specify science pursued as an end in itself, without any regard to any external or ulterior use, the object of the pursuit being the attainment of knowledge and the development of the intellect. The word also fits as this kind of science is developed mainly by teachers.

Nearly all great advance in academic science is, and has been, made by professors in universities and colleges and their assistants—or, in short, by teachers. It might be supposed that a body undertaking the education of young men would choose the man best able to explain matters to students. This is not the practice, however. A university gets the most eminent scientific man available, or chooses a young man who promises to become eminent. He is given every assistance to make himself as famous as possible as a scientific discoverer, and apparently scientific distinction is his sole aim, the education of the students being of no account. This curious arrangement seems to work splendidly. It secures men of great ability, and they do good work, which would hardly be done otherwise at all; and instead of the students being neglected, they get fired with their leader's enthusiasm, and become assistants and co-workers, and eventually carry on the great work themselves.

We have thus academic science; we also have utilized science or technology. The technologist, as such, is not interested in the fabric of organized Nature knowledge or academic science. He takes bits of the knowledge and uses them in manufacture. Sometimes the technologist is first, and his work is fitted into its place in academic science afterwards. Academic science generally develops it, so that the technologist is helped further forward. The technologist generally studies the branches of science which concern him till he knows more about them than those who have the more balanced knowledge of academic science. But this is not all: he has to look at matters from a different standpoint. He has always to consider prices and costs. He has to make his works pay. An engineer is one who makes for \$1 what any fool can make for two. This obviously American definition, of course, covers the chemical manufacturer, and, in fact, every other manufacturer.

Academic science thus does not cover technology. The knowledge is not there in the right form, and it is not in the right proportion, and it is entirely independent of all questions of cost, which are fundamental in technology. Here we have the great difficulty. The science teacher and the general public confuse academic science and technology, and think that the science taught at school or at the university is what is wanted in industry. This is a serious mistake. The teacher especially

is apt to assume that academic science includes technology. It has been suggested that Faraday could have made a fortune by devoting his abilities to industry. He was about as well fitted for success on the turf. It is often said that this or that eminent professor could have made untold wealth if he had stooped so low, but he preferred to labor for a higher object. Of course, this is all nonsense; all men work in competition for the approval of their fellow creatures. Some like to earn it by advertisement and other easy methods, but the student of science is satisfied to earn it only by intellectual effort, but all the same that is his real motive. The case of Cavendish is difficult to understand; but, speaking broadly, fame is the reward sought by the man of science, though he does not say so as naively as the poet.

The idea that academic science includes technology does harm in several ways. It prevents the science teacher understanding technology or realizing what the manufacturer wants. It leads to his looking down on manufacturers as ignorant people, because they have not his particular kind of knowledge. The standpoint that academic science is all important and technology something outside it and quite inferior is, as far as I understand the position in France, the French Academy view. The standpoint that academic science includes technology, or renders any special knowledge of technology unnecessary, is the Royal Society point of view. A few technologists are fellows of the Royal Society, but it is essentially a non-technical society, and much harm is done by its being put forward to deal with technical or industrial matters. There are technologists among the fellows, but the society is essentially untechnical. There are good technical men at the Bar, but it would be absurd for the Government to apply to the Bar Council for scientific advice. It is not true that industry is unscientific either in France or in England, but it will be much better when they get rid of the Academy attitude over there and we get beyond the Royal Society view.

The question is, What ought universities to do? The obvious answer is that they should drop academic science and cultivate only technology. When a course seems quite obvious, and is not at once followed by competent people, it is generally wrong. If we dropped academic science we would drop technology, too, and lose all. Academic science depends almost entirely on universities, and great technological advance is possible only in conjunction with academic progress. In fact, it is like happiness: you can only get it by striving for something else. The universities of the country cultivate virtue in the form of academic science, and the country gets happiness in the form of industrial success. But while cultivating virtue it is foolish to despise any happiness that may come along as an indirect result.

The spirit of academic science does not necessarily render a man less useful as a technologist. Quite the reverse. As long as it does not lead him to look down on technology or to think he knows all about it without any special study it helps him.

Whether it is possible to teach technology satisfactorily in college courses is an open question. A professor of academic science can be in the van of his subject, as he is himself taking part in it. A professor of any branch of technology must be behind his subject, as he has to learn from what is going on in works, which in many cases are not open to him at all. No commercial works wants college professors loose in them, attempting to keep up to date in practical matters. All he could hope to teach satisfactorily would be such matter as can be found in text books, the text books

being written generally by other teachers, not by practical technologists.

The education of technologists, and especially of engineers, has been discussed from many points of view, and anything I could say would be a personal opinion and therefore of little value unless I gave reasons which made it something more. I hold that the training at the university should be on thoroughly academic lines, because those are the lines on which the teachers are able to go far and well, and the whole of a student's available time is not too long to be devoted to a good groundwork of systematic coherent knowledge on which he can raise any desired superstructure of technology. The point I would insist on again is that he must not confuse the foundation with the superstructure. Though I am advocating the development of academic and not practical science at universities, I am not putting forward another argument, and that is the greater educational value of academic science. That is outside my subject, and I might be told I am not an expert on education. I do not know whether I am or not, as I do not know what an educationalist is, or what the symptoms are. Many think that professors and schoolmasters are experts in education. You might as well say that a shunting engine is an expert in locomotion. Those who take interest in the community want to get the locomotives off the old lines on to tracks suitable for the times, and such changes can be made by outside influence only against the bitterest conservatism. That education always sidetracks into useless absurdity is not due to any inherent wickedness of schoolmasters; it is the result of a kind of evolution, and is unavoidable.

Imagine, for instance, a school absolutely practical and sensible and perfectly in touch with real life. When a set of students grew old enough to leave, the most practical would go into outside life and a small selection would go into the teaching profession. This selection would not be deficient in ability, but it would be made up of the less practical, and more pedagogical men. In their generation as teachers the school would thus be a little more out of touch with life than before, and the next generation of masters would be the least practical of a batch of students themselves less practical as a whole; and the school would in due course get more and more senseless until it got down to the ordinary state. Educational institutions thus always contain the growing germs of their own ruin, and do so unavoidably. The teacher's position on a pedestal, his contact with the immature mind only, and his immunity from contradiction tend to foster the rapid growth of the germ. Outside influence ought to affect education, but has no power over it. Parents might control it by sending their sons where it is good and not where it is bad, but they do not care. A father will say: "Tom's education? Oh, yes. My father was at Rugby and the 'Varsity, and so was I, so, of course, Tom goes, too. I had the ordinary education of a gentleman, and I am all right. There's nothing like the regular English public school and 'Varsity education." Closing the matter with this fact, he reconcentrates his attention on the study of "How to Train a Sporting Dog."

Universities do not train men to earn their living by practice in law, and more specially in medicine and surgery. How far our training is good I do not know. A medical man must go through either this course or one of the same kind before he is allowed to practice, so there is nothing to compare it with to see if it is good. If it is, universities have solved the problem of giving a technical as opposed to a purely academic course, but this needs the connection with hospitals. Nothing analogous is available in industry. If industrial concerns which are ill financially turned themselves over to the

treatment of university professors and students they might come to make big profits, but there is some doubt about it.

Imitations of engineering and chemical workshops have always the drawback that they are only imitations. The elements of time and price do not come in, and they are vital.

Technical schools, unlike universities, have the definite object of training students to make their living in industry, and they make their course as practical and as little academic as possible. A technical school is sometimes connected with a university, and we cannot in any case consider university training for industry without taking technical colleges into account. It must be admitted that if the best type of science training, even for industrial use, is the academic, the technical colleges are on wrong lines, and as technical colleges are doing splendid work, the idea put forward appears to be wrong. But it is not urged that the academic training is the best in every way, but that, on the whole, it is best because, first, the professors are able to effect it best; second, because a student has so little time to spare that it can best be laid out in acquiring a good, sound foundation; thirdly, a well trained mind with the academic can easily acquire the technical outlook, too; and, fourth, because academic science trains the mind to reason rather than to memorize, and deals with the facts of nature instead of the ideas or doings of other men just as foolish and illogical as ourselves. More than this, if the universities converted themselves into technical colleges, academic science and with it technology would get moribund. Whether technical colleges are on the best lines is another question. They may be badly designed for training the best class of technologist, while well suited for doing the best for men who have little time, and must be content with an inferior general foundation and a superstructure which is to a great extent imitation technology.

Recently we have heard a great deal about universities helping in scientific research. Research in academic science has little to do with national industry. All such research is published, and technologists all over the world utilize the results wherever the research is carried on. Research in academic science has no direct effect on national industry, but it has a great influence in rousing scientific enthusiasm, which is most important. But the outcry for scientific research for the benefit of industry is made chiefly by people who have no clear idea of the difference between academic and technical research, or of their circumstances. It is largely due to science teachers backed up by newspaper writers. The idea behind it is that manufacturers are ignorant and unscientific, and science teachers could put them right if allowed the chance. For example, we are told repeatedly that we are wasting coal, first, by burning it in badly designed furnaces; secondly, by refusing to extract the valuable hydrocarbons and ammonia; and that it will soon be used up at present rates and England will be ruined. As to the last point, coal that costs a consumer 10s. a ton is worth only a few pence in the ground to the owner. The rest of the cost is labor, carriage, interest on capital, profits, and so on. The present value of money at industrial interest a hundred years hence is about a hundredth, so that unless coal in the ground is going to be more than 100 times as valuable a century hence it pays better to sell now. If coal is worth 6d. a ton in the ground now, it pays the country better to use it at once than to wait for a century if it will then rise to 50s. But carriage from elsewhere will always keep it below any such fancy figure at £2 10s. a ton in the ground. Take the question of extracting the hydrocarbons and ammonia. It is ridiculous for

science masters to tell technologists to extract valuable constituents. They are quite aware of the waste that goes on, and know that it will be reduced in the future. The technologists know infinitely more about coal distillation than the science masters, and they know what can be done commercially now and what cannot. If the science masters made some discoveries that could be utilized well and good, but to tell technologists that they are extravagant and ignorant is quite useless.

Can industrial research be carried on in teaching laboratories? During the war excellent work has been done, more especially in connection with such matters as dyes, drugs and glass. In these cases we were merely taking substances that had already been made and finding out how to make them. Finding out how to produce an existing dye is little in comparison with inventing the dye. The inventor did not know beforehand that there was any possibility of such a dye. After the war a number of undergraduates might be set to experiment on organic substances in the hope they might hit on something new and valuable. Such work would have no educational value, and its commercial result would be small. If one of them produced a new dye that got more brilliant the more it was sunned who would own the patent?

The vague idea seems to be that manufacturers have a number of definite problems they want solved, but they are too ignorant to solve them. They ought, therefore, to seek the advice of the universities, who would put them right. Manufacturers have no such problems. If you went to a cotton mill and asked the manager what problem he wanted to have solved, he might say, "You had better look round and see for yourself," or he might say something really quite different. If you went round you would find everything just so. No doubt every part is really capable of improvement, but no improvement suggests itself. Half or more of the merit of an invention is realizing that an improvement is wanted in any particular machine or process. One of the greatest difficulties the inventor has is to discover the "long felt want."

Take the question of recovery of hydrocarbons and ammonia from coal; students may carbonize coal in bits of gas barrel. This will not give much information as to the habits of a full-sized gas retort, but it may give some. Then they may distill tar, and fractionate the distillates and investigate them, but everything will be on a small scale except the mess. It is not the least likely undergraduates would find out anything in this way and teach it to manufacturers, and they would be merely wasting time and learning practically nothing. They might work under a professor, but it is a mistake to suppose a professor of organic chemistry knows the technical problems of tar distilling. Much of the chemistry is very special and otherwise uninteresting, but if the professor is going to master not only the special chemistry, but the commercial values of all the oils and the costs and practical merits of all the processes, he will have to give up his first-hand academic science to get time to fill himself up with second-hand technology.

But even if a research on tar distillation, for example, could be carried out satisfactorily in an educational laboratory, it could not be carried out in connection with an industrial distiller, because he would not work in with the laboratory unless he was to have a monopoly of the result. If the work is for publication, the tar distiller is not in the least interested, as it concerns his rivals here and abroad as well; so he will give neither information nor help. Results which are to be the common property of all, British or foreign, do not appeal to the individual manufacturer.

There is also a confusion between research and inven-

tion. It is not the least use turning a man or a group, and least of all a committee, on to invent. A committee of science professors would be as fit to make an invention as a council of professors of literature to fabricate a lyric. Industrial progress depends on invention, and we are the most inventive people in the world, not because we are the cleverest, but because we are the most individualistic and the least benumbed by education. Working out dye, scents and drugs is hardly invention; it is a rather lower type of chemical drudgery, which is above routine analysis, but much below original academic research. The better women chemists might tackle it. Inventions may be divided into two classes—improvements in machines or processes which can be made only by those in close touch with them inside the works, and broad inventions, which are generally made by complete outsiders whose minds are not in conventional grooves. In neither case can the university help.

Nothing is said about the shortcomings of the manufacturer, because I am not addressing him. He will not employ scientifically trained men, and he will not think very much of science generally until he finds that the technically trained men come to the front. Politicians, journalists, novelists, prelates and other superior people tell them they are going to the dogs. They make no reply, except such as can be gathered from the trade returns of the country. But the talking fraternity do not read trade returns. English manufacturers are, I maintain, the most competent of all. Eventually they may be better and they may employ science more, but to get them to do so science must adapt itself to industrial application.

I remember our chairman putting it that a man finds himself surrounded by a jungle of ignorance. He has not power or time to make roads in all directions, with cross roads, alleys and paths everywhere, so as to be acquainted with all the trees in the forest, and still less could he keep the ways all clear, as this means constant use of all of them. The best course is to make a few good roads in main directions, and to keep these in repair. He has then only a short path to make to get to any point. Thus, he ought to have a clear idea of the kinetic theory of gases, that is a very useful main road; the theory of the benzene ring; the principle of chemical action often going so that water is formed; the second law of thermodynamics; the conservation of energy; and the principles of mathematics, to mention a few main roads. Put in other words, this means that the technologist should have a thorough grounding in academic science, technology being added afterwards, and the university will have quite enough to do in supplying the groundwork as it ought to be.

Returning to the contention that education should have four chief aims: First, to enable one to earn his living; second, to enable him to live in good health; third, to make him a good citizen; and, fourth, to fit him to enjoy leisure when he has earned it. I would like to touch on a branch of the third.

Industry does not by any means depend alone on the types of science we have discussed. As a whole, it may be helped by the members of the community knowing something of economics, and acting on their knowledge; and it can be obstructed very effectively by the well-intentioned interference of those who know nothing of economics.

I have not been asked to give this lecture as an economist, so, even if I were an expert on the subject it would be unjustifiable for me to put forward conclusions based on political economy. It is, however, within my limits to say something, not as an expert, but as a student of economics, about the national importance of the subject.

Economics is a curious science. Though it is broadly about wealth, it does not help the individual to become wealthy. To an engineer the skillful application of the knowledge of the various physical sciences means success in manufacture which is good for him, and being good for him is good for the country. But a study of economics will not help him directly in his business at all; it is useful to him only as helping to make him a sensible citizen. He becomes a unit of sound opinion on labor problems, and on the action of Government in connection with industry. Unless, therefore, a man has the peculiar bent of mind which makes such a subject interesting in itself, he has no motive to lead him to read economics, until he recognizes it as a duty he owes to society.

Economics is peculiar in another way. If you ask any so-called educated man something about chemistry or mathematics, and he happens to know nothing of such subjects, he says so. People know when they are totally ignorant in such matters. But a man who is sublimely ignorant of economics is quite unconscious of his blind spot. He will lay down the law on such subjects as the relations of capital and labor, the birth rate, old age pensions, and, especially, international and colonial trade, with a cock-certainty, and a wealth of catch-words and circumambient balderdash that is almost good enough for a leading article in a daily paper. More than that, he will insist on acting according to his darks, and he is one of the units that determine the acts of the nation.

I will be told that political economy is taught widely at the universities. Something called economics may figure in the timetables and examinations; but it is either not taught at all, or it is not made a live subject. Perhaps, it is put in the wrong group of studies, and taught the wrong kind of student by the wrong kind of professor. I think Bagshot says something of the sort. That it is not taught efficiently is abundantly clear not only by the nonsense talked by what we called educated men on questions involving it, but more especially by the fact that people do not seem to realize that there is any such science. No sensible man would write an article involving a natural science of which he was profoundly ignorant, and if anyone who was not sensible did so, no competent editor would publish his product; but the high-class magazines, the best weekly papers, and, of course, the daily papers, are full of matter based on negative knowledge or nescience of economics. As to politicians, they do not limit their ignorance of science to economics; they make hay of all sciences and all facts with impartial irresponsibility.

It may be argued that I am putting economics on too high a pedestal; that economists are always gradually changing their views, and that they are sometimes narrow. Economists do not need me to bolster up their reputation. Every science is progressive. It is possible that if economics were treated properly even abler men might be attracted into it. At present there is little temptation to first-class men to specialize in political economy. The only goal is a university professorship, or the authorship of a treatise which will be read by other professors, or some of them, by a proofreader; and if I come across a reviewer's copy second-hand, I may cut it.

Not only the industry of the country, but the happiness of our people may depend on economics. At present we have practically the whole of the hand-working classes dissatisfied, and, therefore, unhappy. The social problem is the most important in the world at present. Its solution must depend on economics. Is it not worth while to study economics with such a purpose, instead of trying all sorts of schemes which are eco-

nomically pernicious? It may be true that economics has not so far provided any cut-and-dried way out; but until people realize that the science which ought to shed light on this path exists, and that it ought to be studied and developed, drawing the best intellects to it, there is no hope for any end, or even alleviation of the miseries of civilization.

I would urge that the first step is for the universities to teach economics, in which I include closely related branches of sociology, with the vigor and insight the subject deserves.

After the war, for instance, there will be many internal and international economical questions to settle. Who is going to settle them, and how?

First, public opinion is being educated. Public opinion is a collection of individual opinions. What we call our opinions are generally unfounded and ignorant prejudices that we wrangle about. When we get interested we hunt up all the arguments that we think will back our opinions up. No one with an opinion examines the matter to see whether his opinion is correct. If anyone has no opinion on hand, he gets one from a newspaper. It is manufactured for him ready made by journalists, novelists, publicists, politicians and everybody but those who know. Later, come committees of all sorts of people whose names are known, but not as economists, and they are supposed to command respect. There will be a sprinkling of business men, because there is a popular delusion that business has to do with economics, and that business men understand economical matters in a peculiarly practical way. In fact, the business man is the most dangerous of all, because he knows no more of the subject than other people; and he is not only unconscious of his ignorance, but he is, if possible, more certain he knows all about the matter. The opinion of such a body as a chamber of commerce on after-war trade conditions is most dangerous. It will be accepted as authoritative, it will be stated without any alleged reasons, and it will almost certainly be wrong.

Is it going too far to say that the war would never have come if the Germans had any true knowledge of economics? It is not for me to say. But surely I may say this: The war is either good or bad. If it is a bad thing, a competent general knowledge of economics would have rendered it absurd in the eyes of everybody, and, therefore, impossible.

Such a calamity as the war is not broadly somebody else's fault. It is the fault of all of us, but especially the fault of education, of which universities are at the head, in not educating us in such a way that such a catastrophe is out of the question.

Broadly, the great change wanted is in public opinion. Until people consider knowledge of the world we live in and the economical, sociological conditions of our life, as coming first, and the study of the sayings, doings and languages of other men, especially of those that lived when the knowledge of everything except human nature was in its babyhood, as quite secondary, we will no doubt go on with all the miseries of poverty, disease, discontent and war. Those who cannot get their ideas taken up by their contemporaries always think the simplest way is to get the next generation educated so as to adopt them readily. This is hopeless; education can be improved only by public opinion, and the reactionary tendency already mentioned is so strong that there is no hope of improving public opinion by education, because education has to be improved by public opinion, and it always lags a century or so behind, reacting on and really poisoning the only source of possible regeneration.

(Continued)

The Thermal and Pressure Decomposition of Pentanes and Hexanes*

By Gustav Eglöf

(Contribution from the Havemeyer Chemical Laboratory, Columbia University, No. 236)

With a view to ascertaining the mechanism of aromatic hydrocarbon formation from paraffins and the elimination of fractions from petroleum oils not conducive to their formation, a mixture of pentanes and hexanes was investigated. In a search of the literature upon the thermal decomposition of pentanes and hexanes, the products found were not aromatic in character, but mainly olefinic, dependent upon the temperature conditions. Previous workers had studied only the decomposition products of the gaseous and not of the liquid phase resulting from the reaction—if any liquid resulted under the conditions of their experiments. No attempt had apparently been made to study the liquid products resulting from the thermal decomposition of pentanes and hexanes. Hence, the present paper communicates the results in the formation of the aromatic hydrocarbons benzene, toluene, xylene, naphthalene and anthracene due to thermal and pressure decomposition of a mixture of pentanes and hexanes.

RESUMÉ OF THE LITERATURE

Norton and Andrews¹ passed the vapors of normal hexane, iso-hexane and pentane through a heated glass tube of 15 mm. diameter and 70 cm. in length. As to the thermal decomposition products of normal hexane the following hydrocarbons were identified; ethylene, propylene, butene, amylene, hexylene, benzene and gases unabsorbed by bromine. At a "bright red heat" the products resulting from the decomposition of iso-hexane were found to be ethylene, propylene, butylene, amylene, hexylene, butene, no benzene and gases not absorbed by bromine. Under similar conditions pentane gave the hydrocarbons ethylene, propylene, butene, no benzene and unabsorbable hydrocarbons in bromine. They report finding benzene as a decomposition product of normal hexane and none from the iso-compound or from pentane. They do not report toluene, xylene, naphthalene or anthracene as decomposition products of the three hydrocarbons experimented with. This can only be ascribed to the factors of temperature, contact surface and time, or length of time the vapors were in the reacting zone; the conditions for aromatic formation which were not fulfilled in their experiments.

Haber² in a study of the thermal decomposition of normal hexane came to the conclusion that its primary decomposition was similar to the higher paraffin hydrocarbons in splitting off the terminal group. The normal hexane was passed in the gas condition through a tube $\frac{1}{8}$ in. in diameter and 25 in. in length, at temperatures between 448 deg. C. and 800 deg. C. The hexane showed between the temperatures of 448 deg. and 518 deg. C. no signs of decomposition. At temperatures between 600 deg. and 700 deg. C., however, the gas contained somewhat over 50 per cent of olefins, 34 to 37 per cent of saturated hydrocarbons (of which 70 per cent was methane), and 10 to 13 per cent of hydrogen. He isolated some benzene but does not report any other aromatic hydrocarbons being formed. This is to be expected when one considers the length and diameter of the heated tube utilized in his experiments.

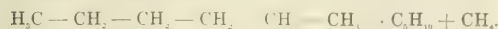
Although the temperatures used in his experiments are high in comparison to those used in the present paper, yet one would expect similar results if the time fac-

*A paper delivered before the organic Section of the 53d meeting of the American Chemical Society, September, 1916.

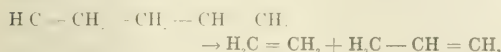
¹Am. Chem. Jour. 8, 1, 1886

²Ann. Physik. 39 (1896), 377, 395, 435, 452, 799, 813 and 830.

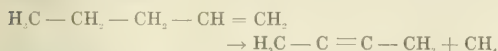
tor for aromatic formation had been maintained at the temperatures Haber used. His work is significant, however, in that he endeavored to show the primary decomposition of normal hexane, which would throw light upon the mechanism of the higher aliphatic hydrocarbon reactions. From a number of experiments he concluded that the primary reaction of the thermal decomposition of normal hexane gave amylene and methane according to the equation:



From the relative amounts of the gaseous and liquid olefins, and the mean molecular weight of the gaseous olefins he concluded that as a secondary reaction a portion of the amylene decomposed to form propylene and ethylene as follows:



From combustion data of the gases formed from the decomposition of the hexane at a temperature of 600 deg. C. and higher he believed that *naphthenes* were likewise formed. Also that by the splitting off of methane from amylene, crotonylene was formed according to the equation:



Haber concluded that the primary decomposition of the higher aliphatic hydrocarbons was by the splitting off of the terminal methyl groups of less than three carbon atoms.

Ipatiew and Dowgelewitch⁷ passed the vapors of hexane through a "tube" at 710 deg. C. The decomposition products analyzed, in the gas, 50 per cent of olefins, 41.6 per cent paraffins, and 8.4 per cent of hydrogen. The individual hydrocarbons were identified as the bromides, ethylene, propylene and probably isobutylene. No aromatic hydrocarbons were isolated or identified.

ANALYSIS OF PENTANES AND HEXANES USED

The mixture of pentanes and hexanes used in the following experiments were derived from "petroleum ether." The petroleum ether was thoroughly washed with c.p. sulphuric acid of specific gravity 1.84 for the removal of any unsaturated hydrocarbons present. The acid present was then neutralized with a sodium hydroxide solution, washed with distilled water and dried over fused calcium chloride. The mixture was distilled by means of a Hempel column and the specific gravity taken by using a Westphal balance at 15.5 deg. C. The analytical results are expressed in Table I.

TABLE I—SPECIFIC GRAVITY 0.656/15.5 DEGREES C

Temperature, Degree C	Per Cent by Volume	Specific Gravity, 15.5 Degrees C.
27	First drop	
27 to 40	36.0	0.630
40 to 60	29.0	0.655
60 to 70	31.2	0.660
70 to 71	Dry point	

EXPERIMENTAL METHOD

The mixture of pentanes and hexanes was passed through a heated lap-welded steel tube of 1½ in. diameter and 72 in. in length at temperatures of 450 deg., 500 deg., 650 deg. and 725 deg. C. Sixty inches of the steel tube were heated by means of 12 gage nichrome resistance wire, three turns to the inch insulated by means of mica or asbestos sheets from contact with the

steel tube. At the middle of the tube a ¾-in. pipe of 6-in. length was welded and a base metal thermocouple inserted through a stuffing box. The electric furnace was set in an 8-in. square steel case packed with asbestos packing for insulation. The liquid was passed into the heated area at a definite rate of 300 cc. per hour by means of a lubricating cup device of 900 c.c. capacity. Six hundred cubic centimeters of pentanes and hexanes was used in each experiment. The rate of oil flow was carefully maintained since even slight variations in this factor would give appreciable differences of percentage yields of the various products resulting from the thermal and pressure decomposition of the starting material. The base metal thermocouple was calibrated against a platinum-iridium thermocouple and was found to be accurate within plus or minus 5 deg. C.

The pressure of the system when using twelve atmospheres was built up by means of an air compressor using natural gas for these experiments. When twelve atmospheres pressure were shown on the gage the compressor was shut down and the oil flow started. As the decomposition of the pentanes and hexanes took place the products of the reaction passed on down through an adequate condensing system consisting of a steel worm packed in an ice-water freezing mixture. The pressure of twelve atmospheres was maintained by means of a globe valve and was not allowed to vary during the experiment.

The analysis of the recovered oils for aromatic content has been given elsewhere.⁸

DISCUSSION OF EXPERIMENTAL DATA

A. TABLE II—PERCENTAGE OF CARBON, GAS, AND OIL, AND SPECIFIC GRAVITY OF THE RECOVERED PRODUCTS AT VARIOUS TEMPERATURES AND PRESSURES

Temperature, deg. C.	450	500	650	725		
Pressure, in atmospheres	1	12	12	1	1	
Per cent of recovered oil	72.0	49.0	15.1	14.0	6.7	0.0
Specific gravity	0.772	0.778	0.780	0.800	0.901	

As is usual in thermal and pressure decomposition work, the percentage yield on the basis of starting oil decreases with increase of temperature and pressure. In going from 450 deg. C. to 725 deg. C. at one atmosphere pressure the percentage yield decreased from 72 per cent to 0.0 per cent. By increasing the pressure to 12 atmospheres, the yield of recovered oil decreased from 49 per cent at 450 deg. C. to 0.0 per cent at 650 deg. C. An increase to 12 atmospheres pressure decreased the temperature of total decomposition of the starting oil, to carbon and gas, 75 deg. C. Greater decomposition of the pentanes and hexanes took place at the elevated pressure when the temperature was held constant. At 550 deg. C. 12 atmospheres gave 86 per cent of the initial oil as carbon and gas, while one atmosphere pressure gave a 55.9 per cent value at the same temperature.

The specific gravity of the recovered oil increased with rise of temperature and pressure, as expected, due to the formation of aromatic hydrocarbons of the benzene, naphthalene and anthracene series from the much lower specific gravity paraffin hydrocarbons, pentanes and hexanes.

At the lowest temperature used, in these experiments, 450 deg. C. and atmospheric pressure, the highest percentage of aromatic compound formation was xylene 8.2, which would indicate that the methyl derivatives of benzene formed more readily than benzene;

⁷Berichte 44, 2987, 1911

⁸Engell and Twiss, *Ind. Eng. Chem. Anal. Ed.*, 1916, 8, 200

B. TABLE III—THE PER CENT OF THE AROMATIC HYDRO-CARBONS IN THE RECOVERED OILS

Temperature, degree C.	450		500		650		725
Pressure in atmospheres.	1	12	1	12	1	12	1
Per cent benzene	2.0	6.5	2.9	13.8	15.1	0.0	0.0
Per cent toluene	6.9	4.2	6.4	5.0	5.9	0.0	0.0
Per cent xylene	8.2	5.8	6.1	2.4	5.0	0.0	0.0
Per cent naphthalene . .	2.1	2.8	3.8	4.8	5.6	0.0	0.0
Per cent anthracene . . .	0.8	1.9	2.8	4.0	4.2	0.0	0.0

for at the same temperature toluene formed to the extent of 6.9 per cent, while benzene gave only 2 per cent. But when the pressure was raised to 12 atmospheres the percentage yield of benzene increased above that of either xylene or toluene. The increase for benzene was 4.5 per cent over the atmospheric pressure condition and the decreased percentage yield of the xylene and toluene together was 5.1 per cent, while the naphthalene increased 0.7 per cent and the anthracene 1.1 per cent under increased pressure conditions, which would lead one to believe that the xylene and toluene formed under atmospheric pressure, in the main, decomposed to form the benzene, naphthalene and anthracene at the elevated pressure. This is strictly in accord with Le Chatelier's principle of those products forming most readily which diminish in volume under pressure. Of course, it can readily be understood that no one of these reactions takes place by and of itself, for side reactions are taking place which profoundly influence the products resulting.

The data at 500 deg. C. give somewhat similar results, although the benzene increased over 450 per cent when the pressure was raised to 12 atmospheres, which percentage is not indicated to be all derived from the percentage decomposition of the xylene and toluene.

At 650 deg. C. the maximum formation of benzene is shown at atmospheric pressure, while a change to 12 atmospheres gives the total decomposition of the starting oil to carbon and gas. The total decomposition of the starting material to carbon and gas takes place also at atmospheric pressure and 725 deg. C.

Increase of temperature and pressure was favorable to the formation of naphthalene and anthracene, which is in accord with earlier findings from the thermal decomposition of high boiling point aliphatic hydrocarbons.⁴

C. TABLE IV—ANALYSIS OF THE PER CENT OF THE AROMATIC HYDROCARBONS ON THE BASIS OF PENTANES AND HEXANES USED

Temperature, degree C.	450		500		650		725
Pressure in atmospheres.	1	12	1	12	1	12	1
Per cent benzene	1.4	3.2	1.3	1.9	1.0	0.0	0.0
Per cent toluene	5.0	2.1	2.9	0.7	0.4	0.0	0.0
Per cent xylene	5.9	2.7	2.6	0.3	0.3	0.0	0.0
Per cent naphthalene . .	1.5	1.1	1.7	0.7	0.4	0.0	0.0
Per cent anthracene . . .	0.6	0.9	1.2	0.6	0.3	0.0	0.0

When calculating the percentage of benzene, toluene, xylene, naphthalene and anthracene upon the basis of pentanes and hexanes used, the percentage relationship changes widely from the value for these substances in the recovered oil. The per cent of benzene, toluene and xylene decreases with increase of temperature. The naphthalene and anthracene reached a maximum with increase of temperature but decreased with increase of pressure. The formation of benzene increased with increase of pressure while toluene and xylene fell off in percentage yield.

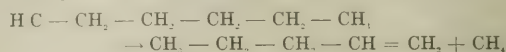
The maximum formation of benzene occurred at 450

deg. C. with 12 atmospheres, and for toluene and xylene at the same temperature, but at one atmosphere pressure.

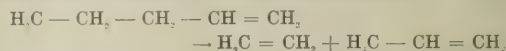
MECHANISM OF THE REACTION

In the thermal and pressure decomposition of the mixture of pentanes and hexanes under the conditions of the present experiments the main products of aromatic type in the liquid phase were benzene, toluene, xylene, naphthalene and anthracene. From the experimental data and conclusions of previous workers as to the products formed in the gas phase from the thermal decomposition of pentanes and hexanes there will be built up a mechanism of aromatic formation mainly deduced from the hydrocarbons isolated from the reaction.

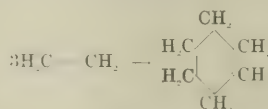
Haber⁵ indicated quite clearly that the primary decomposition of normal hexane resulted in the formation of amylene and methane according to the equation:



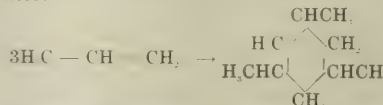
and that a secondary reaction then takes place which results in the formation of ethylene and propylene from amylene, as shown by the following equation:



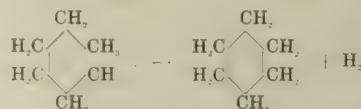
From combustion data he concluded that naphthenes were also formed in decomposing normal hexane. From this it can readily be seen that 3 moles of ethylene can form 1 mole of hexahydrobenzene according to:



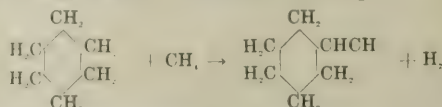
and that 3 moles of propylene can readily form 1 mole of hexahydromesitylene as the following equation indicates:



A purely hypothetical formation of hexahydrobenzene from the splitting off of hydrogen from the terminal carbon atoms of the normal hexane can be shown quite similarly to the formation of naphthenes by means of the Freund reaction or the Perkins method by use of the brom derivatives and sodium. The following equation illustrates the reaction:



From the methane formed as primary decomposition product, according to the first equation, reacting with the hexahydrobenzene from either of the two above ways, hexahydrotoluene could form according to:



The two last equations are purely hypothetical.

De Montmolin⁶ has analyzed the complex mixture of

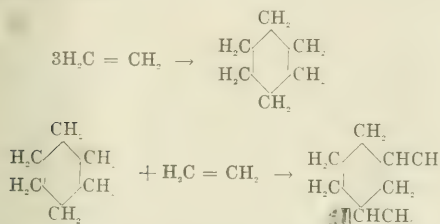
⁴Jour. Gasbel, 39 (1896), 377, 395, 435, 452, 799, 813 and 830.

⁵Bull. Soc. Chim. 19, 242, (1916).

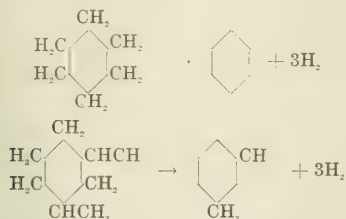
⁶McGoff and Twomes, Jour. Phys. Chem. 20, 121, 1916.

hydrocarbons formed by the action of phosphoric acid and alcohol in producing ethylene. This hydrocarbon liquid was composed mainly of the polymethylenes-cyclohexane homologs, together with saturated and unsaturated aliphatic hydrocarbons with some aromatic substances also present. The following substances were isolated in a pure condition: di-isopropyl, dimethyl-diethyl methane, hexahydro-m-xylene and hexahydro-p-xylene as also hexahydrocymene and hexahydrocymene.

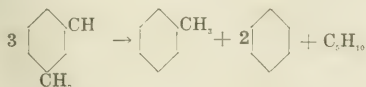
From this evidence of the polymerization of ethylene to alicyclic compounds the formation of aromatic hydrocarbons from such polymethylenes by decomposition from thermal and pressure conditions can be readily followed. It is well known that ethylene is one of the decomposition products of all paraffin hydrocarbons subjected to temperature and pressure conditions, and with the exception of methane persists longest as a product of the reaction. The synthesis of hexahydrobenzene can be readily followed by means of ethylene first forming hexahydrobenzene and then reacting with 1 mole of ethylene forming hexahydroxylene as shown by the following equations:



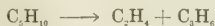
Now these naphthenes or better termed alicyclic hydrocarbons are not stable at elevated temperatures, decomposing readily to the aromatic hydrocarbons benzene and xylene (o) (m) (p), and splitting off hydrogen in the reaction. The equations following illustrate the direction of the reaction at the temperatures and pressures used in these experiments:



In previous work¹ it has been shown that the three isomers of xylene decomposed, with a tendency to form toluene, benzene, naphthalene and anthracene. Now 3 moles of xylene can readily give 1 mole of toluene, 2 moles of benzene and 1 mole of amylene, as follows:

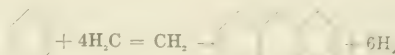


The amylene formed would, according to Haber², decompose to form ethylene and propylene:

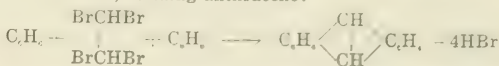


The work of Ferko³, who passed ethylene and benzene through a "hot" tube isolated as one of the decomposition products anthracene, but no naphthalene. The

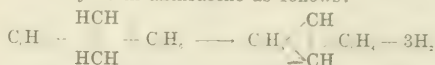
mechanism of anthracene formation may possibly be as follows:



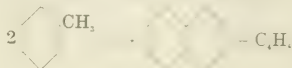
The more probable reaction in the formation of anthracene, however, is by an analogous one of Anschütz, who treated tetrabromomethane and benzene with aluminium chloride, forming anthracene:



Instead of tetrabromomethane being used, ethylene could quite readily form anthracene as follows:



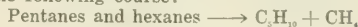
He also showed that one of the decomposition products from the thermal treatment of toluene was naphthalene, as also did Rittman, Byron and Egloff.⁴ The course of the reaction would probably be as follows:



The resulting products being naphthalene and butylene. Norton and Andrews⁵ found butylene in the thermal decomposition of normal hexane, but do not report any formation of naphthalene.

Due to the dominancy of Berthelot's theoretical conclusions as to the mechanism of aromatic formation from low boiling hydrocarbons, upon scant experimental evidence other workers in the field have taken his lead in indicating the apparent necessity of passing through the acetylene stage of polymerization to benzene and then to higher homologs. From the experimental evidences of the various workers this cannot be true, for in most cases no acetylenes were found, although special precautions were taken to isolate same, and wherever found were present only in slight amounts. That acetylene polymerizes to form benzene is certain, but as to whether the main source of aromatic hydrocarbons resulting from the thermal decomposition of paraffin hydrocarbons via acetylene formation is more than questionable. From the experiments of decomposition of the mixture of pentanes and hexanes at the low temperatures used in this series, it is doubtful that acetylene or its homologs are formed.

From the experimental evidence gathered the mechanism of the reaction in the formation of aromatic hydrocarbons from the aliphatic hydrocarbons used indicate the following course:



Naphthenes (alicyclic hydrocarbons)

Aromatic hydrocarbons.

GENERAL DISCUSSION

A mixture of pentanes and hexanes is conducive to aromatic formation at low temperatures. At elevated temperatures the decomposition of the mixture goes totally to gas and carbon. From the experimental evidence of previous workers and the present set of experiments a mechanism of aromatic hydrocarbon formation has been built up.

¹Rittman, Byron and Egloff, *Jour. Ind. Eng. Chem.*, 7, 1019, 1915.

²Loc. cit.

³Berichte 20, 660, 1887.

⁴*Jour. Ind. Eng. Chem.* 7, 1019, 1915.

⁵Ibid.

It is quite certain that all paraffin hydrocarbons lend themselves to aromatic formation, even the highly stable methane. The work of Zanetti¹ is significant in that he produced aromatic hydrocarbons from the thermal decomposition of mixtures of ethane-propane; propane and butane derived from the condensate of natural gas. This leaves methane as the main paraffin hydrocarbon which, as far as the author is aware, has not been converted into aromatic hydrocarbons. There is no doubt that under proper temperature, pressure, concentration, time and surface contact conditions, methane can also be converted into aromatic hydrocarbons of the benzene, naphthalene and anthracene series.

SUMMARY

1. A mixture of pentanes and hexanes has been subjected to temperatures of 450, 500, 650 and 725 deg. C. and pressures of 1 and 12 atmospheres for the formation of benzene, toluene, xylene, naphthalene and anthracene.

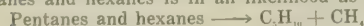
2. The percentage yield of recovered oil decreased with increase of temperature and pressure. The maximum yield occurred at 450 deg. C. and 1 atmosphere pressure. At 650 deg. C. and 12 atmospheres the starting oil decomposed completely to carbon and gas. The same result was recorded at 1 atmosphere and 725 deg. C.

3. The percentage of benzene in the recovered oil increased with increase of temperature and pressure; the maximum of 15.1 per cent was found to occur at 650 deg. C. and 1 atmosphere pressure. The percentage yield for toluene and xylene decreased with increase of temperature and pressure. The maximum per cent for toluene was 6.9 and 8.2 for xylene, both at 450 deg. C. and 1 atmosphere. The percent of naphthalene and anthracene increased with temperature and pressure, giving as a maximum for naphthalene 5.6 per cent and for anthracene 4.2 at 650 deg. C. and 1 atmosphere.

4. The per cent of benzene, toluene and xylene decreased with temperature and pressure increase on the basis of pentanes and hexanes used. A maximum of 3.2 for benzene was noted at 450 deg. C. and 12 atmospheres, while toluene gave 5.0 per cent and xylene 5.9 at the same temperature and 1 atmosphere. The formation of naphthalene and anthracene increased with temperature and decreased with pressure. The maximum for naphthalene gave 1.7 per cent and 1.2 for anthracene, both occurring at 500 deg. C. and 1 atmosphere.

5. A mixture of pentanes and hexanes is conducive to the formation of aromatic hydrocarbons at low temperatures.

6. The mechanism of aromatic formation from pentanes and hexanes is in all likelihood as follows:



Naphthenes (alicyclic hydrocarbons)

Aromatic hydrocarbons.

Columbia University, N. Y. City.
Department of Chemistry.

Zanetti, *Trans. Ind. Eng. Chem.* 5, 671, 1916.
Zanetti and Lando, *Ind. Eng. Chem.* 5, 777, 1916.

The Utilization of Waste Heat for Steam-Generating Purposes*

By Arthur D. Pratt

The utilization of waste heat from various industrial processes for the generation of steam is not new. The advance within the last few years, however, in methods of utilizing such gases and in the results secured from their utilization has been so remarkable as to make of interest a comparison of former with present-day methods and results.

The design of waste-heat boilers has progressed to a point where it is to-day possible to generate steam successfully from gases whose temperatures are as low as 950 or 1000 deg. Fahr. It is but a few years since it was considered absolutely impracticable from a commercial standpoint to attempt to produce power from such gases, and it is in its ability to satisfactorily utilize these gases that the development of the modern waste-heat boiler has its most far-reaching effect.

The sole theory on which early waste-heat boiler installations were made had as its basis the non-interference in the operation of the primary furnace. This meant, in practically all cases, that the draft at the exit of the primary furnace should in no way be impeded, and resulted in the installation of a given amount of heating surface arranged in such manner that the frictional resistance to the gases in their passage through the boiler should be a minimum. Presumably the object of such an arrangement was to enable a natural-draft stack of a practicable height to be used. As the result of minimizing this draft loss, such boilers as were installed were ordinarily entirely without baffles and the gases were given a straight passage through the boiler, though partially baffled boilers were used occasionally. High exit gas temperatures were considered rather desirable than otherwise in order to assist the stack in giving the required drafts.

Boilers installed in this way were considered practicable only with gases whose temperatures approached those of coal-fired practice. The users accepted the steam generated as "something for nothing," and no particular endeavor was apparently made toward increased capacities.

Present-day waste-heat practice has come about with a more thorough understanding of the laws governing heat transfer and an appreciation of the function of gas velocity as affecting transfer rates. Without going into this aspect, it may be broadly stated that the rate of heat transfer is dependent upon gas velocity and temperature difference between the gas and the absorbing surface. Experiments have shown that at even the highest velocities now used in waste-heat work the effect of increased temperature difference is small as compared with that of increased gas velocity.

In coal-fired-boiler practice the average temperature difference between gases and boiler surfaces is approximately 1150 deg. The heat-transfer rate corresponding to a boiler's rated capacity is about 3 B.t.u. per hour per square foot of surface per degree difference, or a heat absorption of 3450 B.t.u. per square foot of surface per hour. In waste-heat work the temperature difference varies widely with the class of waste heat. With a gas temperature, say, of 1250 deg. entering a boiler, the average temperature difference between boiler surface and gas for a working pressure of 170 lb. per square inch will be about 500 deg. For such a temperature difference the transfer rate, to give an absorption per square foot of surface equal to that of the coal-fired boiler at rating, would have to be 6.9 B.t.u. per hour

*A paper presented at the annual meeting of the American Society of Mechanical Engineers on Dec. 6, 1916, in New York. All temperatures in this paper are given in degrees Fahr.

Mining Course for Practical Men.—The twentieth annual short session of the College of Mines of the University of Washington, Seattle, Wash., will open Jan. 2 and end April 1. Courses offered include prospecting, mining, milling, assaying and smelting, and are for the benefit of those unable to enroll for the regular college work.

per square foot per degree difference. This rate is slightly higher than the rates corresponding to velocities that are as yet ordinarily used, but with somewhat higher entering gas temperatures the absorption per square foot of surface is such as to enable a boiler's rated capacity to be developed without difficulty. With gas temperatures entering the boiler of 1800 to 2000 deg., which approach coal-fired practice, high overloads are being developed.

The gas velocities necessary to give what is now considered a desirable transfer rate lead to a frictional resistance through waste-heat boilers which makes the use of a natural-draft stack impracticable. Let us consider what is probably the extreme case in so far as draft conditions are concerned, namely, the open-hearth steel furnace. Common practice in this class of work is to use stacks 160 ft. high, which give a draft at their base approximately 1.4 to 1.6 in., depending upon the gas temperatures. For the present purpose, assume that the draft loss through a modern waste-heat boiler installed with an open-hearth furnace is 2.0 in., a figure which approximately represents the practice of to-day. With a natural-draft stack, the draft at the checkers corresponding to the 1.4 to 1.6 in. given above is approximately 1.3 to 1.5 in., and this amount is necessary for the proper operation of the furnace. With a waste-heat boiler installed, then, the draft necessary at the exit of the boiler must be sufficient to overcome the resistance through the boiler, 2 in., that necessary to overcome resistance through the flues, say 0.75 in., and 1.5 in. necessary at the checkers, or a total of 4.25 in. It is to be remembered that with a waste-heat boiler installed, the temperature of the gases entering the stack, instead of being 1000 or 1200 deg., will be 450 or 500 deg., under which conditions a stack of 160 ft. instead of giving a draft of 1.4 to 1.6 in. at its base would give approximately 0.9 in., and to give the necessary 4.25 in. the stack height would have to be somewhat over 700 ft.

While, as stated, this is perhaps the extreme case, the same reasoning applies in practically all waste-heat work, and an induced-draft unit is now almost universally used with the modern design of waste-heat boiler. In certain classes of waste-heat work, such a fan not only furnishes the required draft suction, but is of a decided advantage in the operation of the primary furnace. This feature will be discussed in connection with the individual classes of waste heat later considered.

As may be inferred from the foregoing, the successful utilization of waste gases becomes more difficult with decreasing gas temperatures. It was in connection with regenerative furnaces and low-temperature gases that the principles of high gas velocity were first applied and the modern waste-heat boiler was developed. The success of the early installations in this particular class of work led to the application of this theory to all classes of waste-heat practice.

Waste-heat boilers of the modern design are in successful operation to-day with copper-refining furnaces, cement kilns, open-hearth steel furnaces, beehive coke ovens, zinc-refining furnaces and heating furnaces of various types, both regenerative and non-regenerative.

As stated, the waste-heat boiler of to-day was developed with low-temperature gases and its largest field, until the present, has been with open-hearth steel furnaces. For this reason this class of waste-heat work will be considered first.

Open-Hearth Steel Furnaces

This particular phase of waste-heat work may be considered new. In the open-hearth steel furnace we have the best and by far the most numerous examples

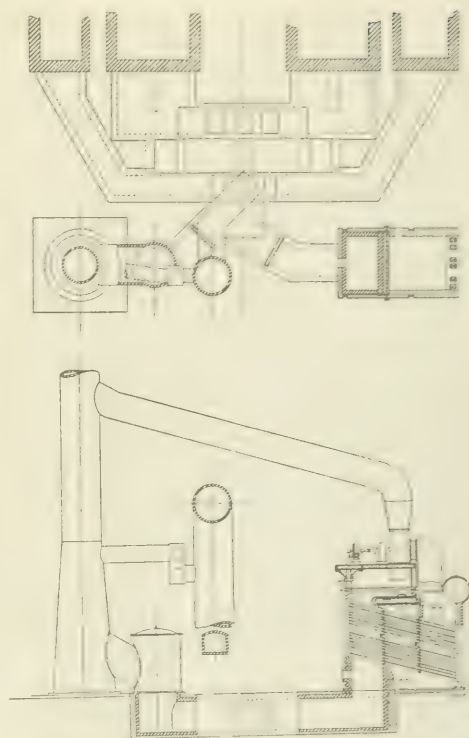


FIG. 1 WASTE-HEAT BOILER FOR OPEN-HEARTH FURNACE

of the regenerative furnace. From the very nature of the operation of such furnaces, gas temperatures passing to the stack are low, and the ability of the modern waste-heat boiler to utilize successfully these gases for the generation of steam is, without question, the best proof of the progress in the development of this particular class of boiler.

An experimental waste-heat boiler for this work, embodying the principles but possibly not the design of the modern waste-heat boiler, was installed at the South Chicago plant of the Illinois Steel Company, in 1910. The results from this installation, while by no means comparable with those secured to-day with the more highly developed design, so clearly indicated possible savings in the practically untried field of open-hearth practice that two boilers, the design of which may be considered well past the experimental stage, were purchased for this same plant in 1911.

C. J. Bacon, Mem. Am. Soc. M.E., steam engineer of the Illinois Steel Company, presented before the American Iron and Steel Institute in May, 1915, a paper, Waste Heat Boilers for Open Hearth Furnaces, in which he describes the experimental boiler referred to, and traces the development in this class of work through the first three installations made.

The first of these, at the plant of the Illinois Steel Company, in South Chicago, consisted of two Stirling boilers equipped with special cross baffles to give the desired gas velocities over the heating surfaces.

The second installation, made at the Gary plant of the Indiana Steel Company, consisted of twenty-eight special 6-drum Rust boilers equipped as in the case of the Stirling boilers with special cross baffles.

The third installation described is that made at the

Pencoyd Works of the American Bridge Co. and consists of a cross-drum Babcock and Wilcox boiler, the width of boiler and the tube length being such as to give the gas-passage areas necessary for the required gas velocity. For low-temperature waste-heat work, the type of boiler of which this installation is an example is in general best suited. Fig. 1 shows a typical layout of a boiler of this last design.

Table 1 gives the results secured from the Stirling and Rust boilers described and from Babcock and Wilcox boilers similar in design to that installed at Pencoyd, though set with considerably larger open-hearth furnaces. That the three installations described by Bacon are truly progressive, at least from the aspect of heat absorption, may be seen from the results given in this table.

Tests 1, 2 and 3 are as given in Bacon's paper and its discussion. Test 4 is included as being of interest in indicating the results that may be secured with gases at a temperature considerably below that ordinarily found in open-hearth work. At this particular plant the gas temperatures leaving the checkers were not appreciably lower than in other tilting furnaces, but the necessary flue arrangement was such that there was an excessive radiation loss between the checkers and the boiler from flues and reversing valves.

In Table 1, as in the following tables, the proper basis for the comparison of results is the rate of heat transfer, but in order that such a comparison may be intelligent, it is necessary in connection with the transfer rates to give proper consideration to the gas weights per square foot of heating surface, entering and exit gas temperatures, and the percentage of rated capacity developed. To give a direct comparison of the performance of two different boilers, the gas weight per square foot of heating surface and the entering gas temperature should be the same.

It is possible from our present knowledge of the laws of heat transfer to compute with surprising accuracy the results that may be expected from any boiler for a given set of conditions. Let us consider, then, the results which the boiler of Test No. 4 would give under the gas conditions of Test No. 1. For a weight of gas per square foot of surface corresponding to Test No. 1, the total weight of Test No. 4 would become 98,950 lb. per hour.

With this weight passing through the boiler of Test No. 4, at the temperature actually existing in No. 4, the boiler would develop approximately 363 hp., or 67 per cent of its rated capacity. With an entering tem-

perature equal to that in Test No. 1, the boiler would develop approximately 500 hp., or 92 per cent of its rated capacity. These figures are included simply to show the importance of giving all factors proper consideration where a comparison of results is to be made.

In connection with waste-heat boilers there are certain features of installation and operation, some of which refer specifically to open-hearth work and others to waste-heat work in general, that are of interest. While these features are discussed here, they will apply in certain of the other classes of waste-heat work considered later.

LOCATION OF BOILERS

The early boiler installations were made with open-hearth furnaces already in operation. With these furnaces it was necessary to connect the boiler to the flue between the reversing valves and the stack, the boiler thus being on a branch flue while the stack was on the more direct connection. It was and is common practice, in laying out open-hearth furnaces, to place the stack central with the furnace, and wherever such an arrangement is followed the boiler would of necessity be on the branch flue.

It is recommended, and to-day this recommendation is being more or less followed, that the boiler be placed central with the furnace and the by-pass stack on the branch connection. Such an arrangement will give a straight gas passage to the boiler, minimizing frictional resistance in the connecting flues due to the absence of turns, and will have a tendency to give an equal distribution of the gases across the width of the boiler.

A further advantage of such an arrangement is that better protection is given to the by-pass stack damper. These dampers are ordinarily of cast iron, and where they close a direct passage to the stack, they are subjected to temperatures considerably higher than if the stack were on the branch connection and this damper installed on such connection.

CONNECTING FLUES

The flues from the reversing valves to the boiler should be as short as possible to minimize radiation losses. The location of such flues, with the same object in view, is also of importance. Ordinarily these are placed underground, and their depth beneath the surface should be such as to furnish a sufficiently thick insulating layer of earth on top. The best practice is to make this layer from 3 to 4 ft. thick. In one installation where, because of certain unavoidable conditions, the thickness of the earth covering on the top of the flue was something less than 1 ft., the temperature of the surface of this earth was over 400 deg. The loss from radiation from such a flue is obvious.

Ample means should be supplied for keeping these connecting flues clean, and the area should be such as to allow a certain amount of accumulation of dust when the furnace is down without impeding the draft. The average life of an open-hearth furnace is probably around 300 heats, though occasionally 350 are obtained. When the amount of dust carried in the gases is considered, it is readily conceivable how there can be an accumulation between furnace lay-off periods that will seriously affect the draft. In one instance where, because of press of work, the connecting flue was not cleaned out during two periods when the furnace was down, the dust had filled the flue to more than a third of its cross-sectional area.

AIR LEAKAGE

Too much importance cannot be attached to keeping flue connections and boiler settings tight in order to minimize air leakage, the effect of which is to reduce

TABLE I—RESULTS OF TESTS OF WASTE-HEAT BOILERS FOR OPEN-HEARTH FURNACES

Test Number.....	1 ¹	2	3	4
Plant.....	Illinois Steel Co., Chicago, Ill.	Indiana Steel Co., Gary, Ind.	Bethlehem Steel Co., So. Bethlehem, Pa.	Lackawanna Steel Co., Buffalo, N. Y.
Location.....				
Rated capacity of furnace, tons.....	65	75	80	60
Actual production, tons.....	724	85	82 6	518
Boiler.....	Stirling	Rust	B. & W.	B. & W.
Heating surface, sq. ft.....	4,000	4,800	5,232	5,407
Superheat, deg. Fahr.....	128	176	121	97
Gas weight, lb. per hr.....	73,000	83,434	75,271	78,047
Gas per hr. per sq. ft. of h. s., lb.....	18.3	17.1	14.4	14.6
Temperatures.....				
Gas entering boiler, deg. Fahr.....	1,227	1,155	1,302	986
Gas leaving boiler, deg. Fahr.....	621	530	403	468
Drop in temp., deg. Fahr.....	606	625	899	518
Draft at boiler inlet, in.....	1.47	1.55	1.55	1.76
Draft at boiler damper, in.....	3.05	3.05	3.29	3.63
Draft loss, in.....	1.78	2.48	1.74	1.87
Gross h.p. developed.....	334.5	393	425.8	306
Per cent of rated capacity ²	85.6	80.6	81.4	56.7
Boiler h. p. to fan.....	3	69 ³	24.3 ⁴	
Net horsepower.....		386	401.5	
Approximate transfer rate (H).....	5.08	6.92	4.77	5.12

¹Average of ten tests.

²Approximate.

³Motor-driven fan.

⁴53 h.p. returned in feed-water heater.

⁵Tilting furnace.

⁶All ratings are on the basis of 10 sq. ft. per h.p.

gas temperatures, decrease boiler capacity, and place an added burden on the fan unit.

The effects of air leakage and the possible improvement in results through its reduction may be shown by an example: One of the early boilers installed was with a small furnace which had been in operation for some time. The boiler was first put into service with no particular attention given to the tightness of existing flues, and a continuous run of 119 hours was started. For the first day or two the gas temperatures entering the boiler were very low, the temperature drop between the checkers and the boiler entrance being some 650 deg. This excessive cooling of the gases was found to be due to air infiltration through the length of the flue and an excessive amount of leakage at the stack bypass valve. Nothing could be done toward remedying the latter defect, while the furnace was in operation, but flue leaks were stopped as far as possible without stopping the test. The reduction in these leaks increased the gas temperatures entering the boiler at the end of the run to approximately 1000 deg., as against 600 to 650 deg. at the start. The average gas temperature entering the boiler during this run was 855 deg.

The furnace was then shut down, the sources of air leakage more thoroughly gone over, and the leaky dampers repaired and sealed. A second run of 120 hours was then started, during which the average gas temperature entering the boiler, with the furnace conditions as nearly as possible like those in the first run, was 1153 deg. The loss between checkers and boiler was reduced to approximately 300 deg., most of which was due to a faulty reversing valve that could not be repaired without replacing.

The results of the two runs, showing the effect of reducing leakage, are as follows:

	Run No. 1	Run No. 2
Gas entering boiler 100°	8.08	10.19
Gas temperature entering boiler	11.16	8.29
Gas temperature leaving boiler	855	1,153
Draft boiler damper	425	479
Draft boiler inlet	3.99	3.77
Draft drop	1.85	1.85
Steam to fan engine (in terms of boiler horse- power)	2.14	1.92
Horsepower developed	35.7	28.1
Per cent of rated capacity	132.4	200.2
	53.8	81.4

It is of interest to note from these figures that by minimizing the air leakage the draft loss through the boiler was reduced 0.22 in., which made possible a lower fan speed with a considerably higher economical rate for the fan turbine. A saving was effected of 7.5 b.-hp. for the fan drive, and there was an increase of 67 gross horsepower. Although this may be an extreme case, the enormous gains secured by reducing the air leakage to a minimum are obvious.

Air leakage through the flues can be minimized through proper design and location. Leakage through the boiler setting is reduced by the use of a compact design, well-erected and bricked in, with precautions to prevent leakage about all cleaning and dusting door frames. Much can be done by painting the settings with asphaltum paint.

CLEANING

As has been stated, the waste gases from open-hearth furnaces are very dirty; and because of the low temperatures, it is, perhaps, of more importance in this class of work than in coal-fired practice that the heating surfaces be kept clean. In the early installations, fears were expressed that dirt would have a tendency to stick to the tubes and be difficult, if not impossible, to remove. Experience has shown, however, that ordinary methods of dusting give perfectly satisfactory results.

In practically all plants now operating waste-heat

boilers in connection with open-hearth furnaces, the boilers are dusted once in 24 hours. In one plant which operates eleven such boilers and in which the results are checked perhaps more closely than in the average steel plant, the engineers have concluded as the result of actual experience that it pays to dust every 8-hour shift.

Some figures showing the effect of dusting on exit-gas temperatures are of interest. In a certain plant a series of tests were run with cleaning intervals of 20, 10 and 6 hours. When the boiler was allowed to go 20 hours without cleaning, the reduction in gas temperatures after cleaning was 60 deg.; where the cleaning intervals were 10 hours, 50 deg., and where 6-hour intervals elapsed, the reduction varied from 10 to 30 deg. In a second plant, with larger boilers, after an undusted period of 24 hours, for an unchanged entering temperature the exit temperature was reduced 35 deg. by a thorough cleaning. In this instance, with the gas weight passing through the boiler, this 35-deg. reduction was equivalent to an increase of 22 hp. This increase in capacity would not, of course, hold over a period of 24 hours, but it would appear conservative to state that the 24-hour cleanings for such conditions would correspond to at least a net saving of 10 hp. as against 48-hour cleanings. At \$40 a year per horsepower—a rough estimate of the yearly value—this would mean an annual saving of \$400 per boiler.

The draft loss through a clean boiler will be less than through one not dusted; and while the decrease in load on the fan due to cleaning may not be great, it will at least be appreciable.

DAMPERS

Customary practice has been to use a vertical cast-iron sliding damper for the stack by-pass. Considerable difficulty has been experienced in keeping such dampers tight, and where the stack connection, rather than that to the boiler, is the direct connection, difficulty through warping has sometimes occurred. While as far as is known it has never been tried, it would appear that a damper similar in design to reversing valves warranted a trial, in order to reduce leakage at this point. Such a damper would automatically close the passage to the stack when that to the boiler was open, and vice versa, at the same time stopping all air leakage at a point where this might be excessive. It is possible that such a design of by-pass damper would require a small amount of cooling water, but the loss in heat to this water would, it is believed, be more than offset by the gain through reduced air leakage.

EXPLOSIONS

In the operation of open-hearth furnaces certain characteristic explosions are liable to occur during the reversal of gas valves. These vary in intensity from slight puffs to rather heavy explosions, and are caused by a mixture of fresh air with carbon monoxide which must pass off during the operation of reversal. Such explosions, often unnoticed with furnaces directly connected to a stack, become very evident where boilers are installed, and every effort is made to keep flues and settings tight. It was feared, and rightly, that with the installation of waste-heat boilers the heavier explosions might have a destructive effect on the boiler settings and connecting flues. For this reason particular attention should be given to proper buckstay construction, and an ample number of explosion doors should be furnished to relieve the pressure within the setting, should explosions take place.

A thorough investigation of the trouble from explosions showed that by a proper system of reversing-

valve operation the difficulty would be practically overcome; certainly to an extent where sufficient and properly designed explosion doors would obviate the possibility of wrecking or injuring the settings.

A method of reversal that experience has shown gives satisfactory results is as follows: Fig. 2 shows in diagrammatic form a typical layout of checkers, valves, flues, stack and boiler inlet, the valves being indicated by A to H, inclusive, and the checkers I to L, inclusive.

Assuming the gases from the open hearth are passing

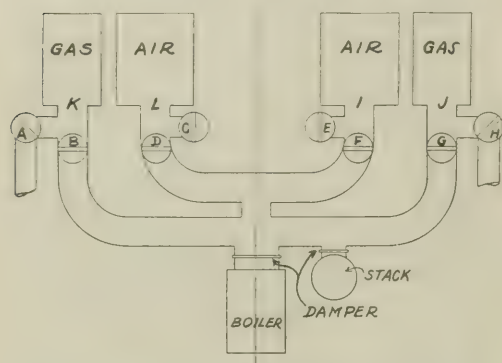


FIG. 2—LAYOUT OF CHECKERS, VALVES, FLUES, STACK AND BOILER INLET

through the gas checkers J and the air checkers I, the order of operation is:

- 1 Turn off steam to producers
- 2 Close air stack valve F
- 3 Close gas inlet valve A
- 4 Close air inlet valve C
- 5 Open gas stack valve B (producer gas held in gas checkers K now passed to boiler)
- 6 Close stack valve G
- 7 Open air inlet valve E (air now admitted to the furnace to give proper combustion upon the opening of the gas valve)
- 8 Open gas inlet valve H
- 9 Open air stack valve D
- 10 Turn on steam to producers.

The essential feature in such a sequence of operation is, of course, to avoid opening the stack valves from gas and air checkers simultaneously, or nearly enough together to allow the hot producer gas and air from the checkers to mingle and ignite within the flues or boiler settings. In this system of reversal the air stack valve D is opened a sufficient interval after the opening of the gas stack valve B to allow the gas pocketed in the checkers K to pass away and mingle with the existing gases before the hot air from the checkers L is admitted to the flues through opening the valve D. In reversing the operation, similar precautions should be taken respecting gas stack valve G and air stack valve F.

In a plant where this system was followed, explosions were reduced from approximately 40 per day (about one each two reversals), varying in intensity, to 4 in 411 consecutive reversals covering a period of five days, and of these 4 but 2 could be called heavy and were directly traceable to a leak in a hydraulic valve which, through the operation of the ram, caused the gas valve to unseat.

This system may be modified for different valves and flue arrangements, but the time between opening the

stack valves and gas and air checkers is the important point.

Another system used is one of interconnected valves, sets of valves being operated simultaneously. Perhaps the best method would be a combination of the two; that is, valves interconnected to assist in manipulation but so arranged that the first order will be followed. The connections should be designed so that sufficient time will elapse between opening the stack valves and gas and air valves to make impossible the mingling of hot producer gas and air.

SAVINGS

Great savings have been made possible by the installation of waste-heat boilers with open-hearth furnaces, and some approximate figures are of interest.

There have been installed, or ordered, over 90,000 rated boiler horsepower for this class of waste-heat work alone. These boilers are set with over 190 open-hearth furnaces, the annual total production of which is considerably in excess of 9,200,000 tons of steel. Experience has shown that through the use of waste-heat boilers the net cost of production of this material is reduced from \$0.20 to \$0.25 per ton, which would mean a net annual saving for the production weight given above of \$1,840,000, using the lower figure.

From another aspect: A conservative estimate of the power delivered by the boilers in this class of work through a year's operation would be 60 per cent of their rated capacity, or 54,000 horsepower. The value of a boiler horsepower in a steel mill varies widely with any number of factors, and ranges from \$35 to \$50 per year. On the basis of the lower figure, which is certainly conservative, the value of the 54,000 hp. produced would represent a saving of \$1,890,000.

Waste-heat boilers, because of their special design, are more expensive than coal-fired boilers, and the expense is increased by the cost of fans, connecting flues, and structural material. The latter expense, of course, is the greatest where boilers are installed with existing furnaces. Regardless of this increased cost, however, the return on the investment is such as beyond question to warrant the expenditure. Mr. Bacon, in the paper to which reference has been made, states that this return on the investment is 60 per cent or over, and recent experience would seem to indicate that this figure is conservative.

In the early days of this work, open-hearth steel furnace operators were fearful that the installation of waste-heat boilers with their fan units would seriously affect the operation of the furnace, and that the production would be cut down, the cause of such reduction being in the necessity of longer heats. By actual experience just the contrary was found to be true, and furnaces equipped with boilers showed a decrease in time of heats.

In one instance a 35-ton furnace equipped with a waste-heat boiler and fan was set in a line with five other furnaces not so equipped. The operation of all furnaces was alike and the size of the heats the same. Over a period of six days the average time of heat for the furnace equipped with the waste-heat boiler was 9.17 hours, while the average for the other five furnaces was 11.17 hours.

Eight different sets of furnaces in all were investigated in connection with the saving in heat length. These furnaces varied in rated capacity from 35 to 75 tons, the actual production ranging from 40 to 87 tons per heat. The normal length of heat in the furnaces connected direct to the stack, from records secured previous to the installation of the waste-heat boilers, averaged, for the 8 furnaces, 12.1 hours. The average

length of heat for the same furnaces, after the installation of the waste-heat boilers, was 10.8 hours, the saving in time varying in individual furnaces from but a few minutes to 2.9 hours. The total tonnage per heat of the eight furnaces in question was 507 tons. The increased tonnage of the 8 furnaces due to the decrease in heat length would amount to 42,000 tons per year, or approximately a 12 per cent increase in the total tonnage of these furnaces.

There is a further saving due to the use of the induced-draft fan with which these waste-heat boilers are equipped. This is in the increased life of the furnace and results from the fact that a fan makes it possible to run economically a heat from a furnace which under ordinary natural-draft conditions would take so long that it would not pay.

Cement Kilns

Strictly speaking, the use of waste-heat boilers in the cement industry is not new. The number of installations, however, has been extremely small, and there appear to have been several reasons for the non-development of such boilers in this field.

It was feared that the installation of a boiler would seriously affect the successful operation of the kilns, though possibly this was not as important a factor in cement practice as in some other work; and in common with other waste-heat installations, there was opposition to the installation of mechanical draft because of the power required. There was a decided feeling that a satisfactory arrangement of kiln and boiler could not be worked out and that, because of the amount of dust carried by the gases, boiler difficulties would develop and maintenance costs be high. Further, with the improvement in kiln design (the first commercially successful rotary kilns were used in this country in 1893) and the tendency toward increased kiln length, gas temperatures were lowered to a point where, as in open-hearth practice, it was not considered practicable, if at all possible, to generate steam economically.

Several attempts were made to utilize the heat in these gases through economizers, but such a small proportion of the total heat was reclaimed in this way, and so much difficulty developed through the choking up of the economizers with dust, that such attempts were soon abandoned.

Prof. R. C. Carpenter, Mem. Am. Soc. M.E., in the *Sibley Journal of Engineering*, March, 1904, describes what is believed to be the first installation of a waste-heat boiler with a rotary cement kiln. This was made in 1902 at the plant of the Cayuga Lake Cement Co., a Wickes boiler of 3065 sq. ft. of heating surface being connected to two kilns 7 ft. 6 in. and 6 ft. 6 in. in diameter by 60 ft. long; each kiln having a capacity of approximately 150 bbl. per day. The waste gases from these kilns were passed through the boiler and economizer and, in addition, coal was ordinarily fired on auxiliary grates. The approximate results obtained from this boiler are given in Table 2. This boiler was removed several years ago because of the necessity for using the space it occupied for other purposes.

In a paper, *Pulverized Coal Burning in the Cement Industry*,¹ Professor Carpenter states that, as far as he knows, the only successful installation of waste-heat boilers in the cement industry was at the Kosmosdale plant of the Kosmos Portland Cement Co. A rather thorough investigation of this subject showed that in the early part of 1915 there were at least two other plants utilizing waste kiln gases for steam generation, and securing results that were considered satisfactory. These plants are the Burt Portland Cement Co., Bel-

TABLE II—Results of Tests of Waste-Heat Boilers for Cement Kilns

Test Number	1	2	3	4
Plant	Cem. Co. Ithaca, N. Y.	Cem. Co. Ithaca, N. Y.	Cem. Co. Ithaca, N. Y.	Cem. Co. Ithaca, N. Y.
Location	Ithaca, N. Y.	Ithaca, N. Y.	Ithaca, N. Y.	Ithaca, N. Y.
Size of boiler, sq. ft.	3,200	3,200	3,200	3,200
No. of tubes, diam. 1 1/2 in.	52	52	52	52
Boiler	3,200	3,200	3,200	3,200
Heating surface, sq. ft.	3,200	3,200	3,200	3,200
Gas weight in lb. per hr.	52,300	52,300	52,300	52,300
Gas pressure in lb. per sq. in.	12.0	12.0	12.0	12.0
Temperature, deg. Fahr.	1,800	1,800	1,800	1,800
Gas entering boiler, deg. Fahr.	1,800	1,800	1,800	1,800
Gas leaving boiler, deg. Fahr.	400	400	400	400
Drop in temp., deg. Fahr.	1,400	1,400	1,400	1,400
Draft at boiler damper, in. H ₂ O	0.45	0.45	0.45	0.45
Draft at boiler fan, in. H ₂ O	0.06	0.06	0.06	0.06
Draft loss, in. H ₂ O	5.82	5.82	5.82	5.82
Gross hp. developed	2.1	2.1	2.1	2.1
Per cent of rated capacity	100	100	100	100
Approximate transfer rate, Btu.	1,000,000	1,000,000	1,000,000	1,000,000

¹Results very approximate.

²Optical pyrometer.

³Rated boiler capacity.

levue, Mich., and the Sandusky Portland Cement Co., at Dixon, Ill.

The installation at the Kosmos plant consists of four Wickes boilers rated at 250 hp. each, each connected to a kiln 7 ft. in diameter by 80 ft. long with a capacity of 340 bbl. per day. The gases leaving the kilns are given a considerable horizontal travel, then a downward path and finally an upward travel, this direction of flow being with the idea of precipitating dust in the downward pass. These boilers are fired with coal on flat stationary grates, and the waste gases are brought into the side of the boiler setting at a point somewhat above the furnace arch.

The installation at the Burt Portland Cement Co. plant consists of four Stirling boilers rated at 320 hp. each. One boiler is set in connection with two kilns 7 ft. in diameter by 60 ft. long, the capacity of each kiln being approximately 225 bbl. per day. These boilers utilize waste gases alone. This installation is more or less typical of the four described, and the general arrangement of boiler, flue and kilns is shown in Fig. 3.

The Sandusky installation consists of seven Stirling boilers, each of 320 hp., each boiler being connected to a single kiln 8 ft. in diameter by 100 ft. long with a rated output of 540 bbl. per day. These boilers were

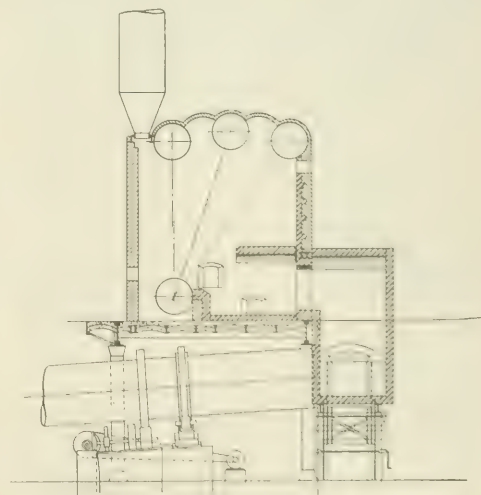


FIG. 3—WASTE-HEAT BOILER FOR CEMENT KILN

¹Trans. Am. Soc. M. E., vol. 36, p. 85.

originally designed for coal in addition to waste heat. Because of low draft available it was found impossible to burn coal economically, and for the past few years firing and ashpit doors have been bricked up and waste heat used alone.

The four installations described were alike in that low gas velocities were used. In the Cayuga Lake and Kosmos plants it is true that induced-draft fans were installed, but this was because economizers were included in the units and not because of any high draft loss through the boiler. In the Burt and Sandusky installations, where the gases were given three passes over the heating surfaces as against two at Cayuga and Kosmos, the baffle openings were considerably larger than standard to minimize the draft loss. As far as can be found, the maximum loss through any of the boilers described was 0.35 in., and it is interesting to compare this loss with that through the modern boiler in this practice.

The exit-gas temperatures from all four of the installations were high, and in the case of the Burt and Sandusky plants enabled a reasonable height of stack to give ample draft for proper kiln operation. The gases leaving the kilns were at temperatures varying from 1500 to 1800 deg. and from 1300 to 1650 where entering the boilers. The generation of sufficient steam to warrant the investment in waste-heat boilers was not particularly difficult with these temperatures. With an increase in kiln length, however, and perhaps with the improvement in burning coal in the kilns themselves, these exit-gas temperatures were reduced very appreciably, and gas temperatures at a point corresponding to a boiler inlet were lowered to around 1150 or 1200 deg., a fact that unquestionably delayed the development of waste-heat boilers in this work.

Success with the low-temperature gases from open-hearth furnaces indicated possibilities in the cement field that aroused considerable interest in the industry and led, in 1915, to the first installation of the modern design of waste-heat boiler with rotary cement kilns. This was made at the plant of the Louisville Cement Co., Speeds, Ind. It consisted of a Babcock and Wilcox boiler containing 15,300 sq. ft. of heating surface and 1382 sq. ft. of superheating surface. This boiler is connected to two kilns 10 ft. in diameter by 150 ft. long. The nominal capacity of each of these kilns was considered at the time of the boiler installation approximately 875 bbl. per day, but with improved kiln operation, and because of the ability to remove the products of combustion from the kilns through the installation of the induced-draft fan, this capacity has reached an

actual output of 1300 bbl. of cement per kiln per day. The boiler is equipped with a turbine-driven fan capable of handling the gases from the two kilns when operated at their maximum capacity, and to furnish a suction sufficient to overcome the resistance through the boiler, through the settling chambers and connecting flues, and still leave ample at the kiln outlet for proper operation. The approximate arrangement of this boiler with its connecting flues and kilns is shown in Fig. 4.

The results obtained from some of the early boilers and those now being obtained from the Louisville installation are given in Table 2. Unfortunately, the data from which the second and third sets of figures are computed are not as complete as could be wished. This is due to the fact that in a number of the tests available coal was burned in addition to the waste gas passing through the boiler, and an attempt made to divide the power developed between the coal and waste gas. A study of different tests, however, some of which were on waste gas alone, enabled us to approximate these results closely, and the figures given are probably correct within reasonable limits. For purposes of comparison with the results secured from the modern waste-heat boiler, they are sufficiently accurate to indicate the enormous gains through the use of such a design.

The gas temperature entering the boiler in Test No. 4 is perhaps higher than ordinarily could be expected with kilns of this size, and until the period during which this particular test was run this temperature probably averaged only slightly over 1200 deg. However, the output of the two kilns during this test was at a point which has since been maintained or bettered, and the temperature in Test No. 4 is representative of present and future practice for these kilns. It would appear that the limiting factor in kiln output, and hence, as affecting boiler capacity, in entering-gas temperatures, is governed by the maintenance cost of the kiln lining.

That the fears which have retarded the development of waste-heat boilers in the cement industry, as outlined at the beginning of this section, have been more or less groundless, is shown by the results secured at the Burt and Sandusky plants over a period of eight years, and to a more marked degree by the very great success, over a period of eighteen months, of the modern design of waste-heat boiler at the Louisville plant.

DRAFT

The installation of waste-heat boilers has not affected kiln operation. At the Burt and Sandusky plants, stacks 135 and 150 ft. high respectively give sufficient draft to overcome the frictional resistance through the boilers and allow sufficient for good kiln operation. The baffle openings in these boilers, that is, the gas-passage area, are, as stated, considerably greater than in coal-fired practice, and the draft loss for the weight of gas passing through the boilers is far less than the loss which would occur with standard areas of gas passage. Further, the gas temperature leaving the boilers is so much higher than is found for any reasonable rating for coal-fired boilers, that the draft suction for a given height of stack is appreciably increased.

At Cayuga Lake and Kosmosdale, induced-draft fans were installed. The boilers at these plants were of a design giving a low draft loss, and the fan installations were due to the economizers. These increased the total draft requirements and the gases were sufficiently cooled by the economizers to decrease the draft for the given stack height well below that obtained at the Burt and Sandusky plants. The draft at the

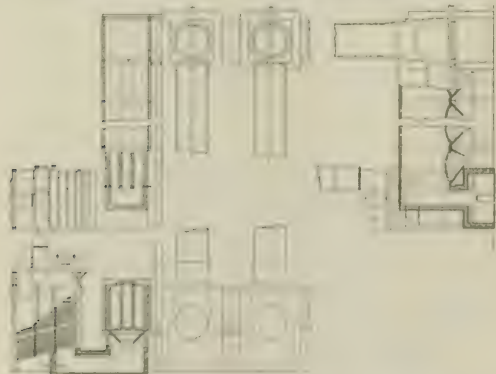


FIG. 4—WASTE-HEAT BOILER, CEMENT KILNS AND CONNECTING FLUES

fan inlet, however, at neither of these plants exceeded $1\frac{1}{2}$ in.

The draft loss through the boilers at the Louisville plant is high. The fan installation, however, running well below its maximum capacity, satisfactorily handles the maximum amount of gas from the two kilns and gives ample draft at the kiln throat for a production greatly increased over that secured before the boiler and fan were put into service. While the increase in production is due primarily to changes in kiln operation and improvements in the methods of burning coal in the kilns, the added draft available through the use of the fan and the ability to handle greatly increased gas weights have unquestionably been of assistance in making this greater production possible.

When the first installations of waste-heat boilers utilizing the principles of high gas velocity and necessitating mechanical draft were under consideration, the operators, as stated, had a strong feeling against the use of fans because of the power required. Experience has shown, however, that with a turbine-driven fan unit the exhaust is just about sufficient to heat the feed of the boiler it serves. It is to be remembered, too, that with all the kilns in a plant equipped with waste-heat boilers, such boilers will furnish practically the entire power required, and the exhaust from the fan turbines will give the only means of feed-water heating.

CLEANING

No difficulty has been experienced in keeping the boilers in this service externally clean. In all but one of the plants investigated the dust has been found to be very light. In the absence of water there is no particular tendency for this dust to stick to the tubes and it may be readily blown off with an ordinary cleaning lance, using either air or steam. Where steam is used, it is perhaps well that this be superheated to minimize the possibility of wetting this dust.

At the Burt plant the practice is to dust with air every 12 hr. During dusting periods the by-pass damper to the stack is partially opened to reduce the draft at the boiler damper with the object of settling as much dust as possible within the setting and connecting flue. At this plant the greater part of the dust was deposited on the level floor in the furnace under the arch, Fig. 3, in the pocket behind the mud drum and on the baffle shelves, there being but little dust that collects on the tubes.

At the Sandusky plant the boilers are dusted with air every 6 hr. Here the boiler is not by-passed when dusting and a considerable amount of dust is blown up the stack at such times. One of the boilers at Sandusky has been equipped with stationary blowers, all dusting doors except those necessary for cleaning out the setting having been bricked up. As far as known, these blowers have given satisfactory service. It is to be recommended that where steam is the dusting medium, with such stationary blowers every precaution be taken to prevent condensation from remaining in the piping system.

At the Louisville Cement Co. plant the boiler is dusted with superheated steam every 12 hr. There has been no difficulty experienced in keeping the boiler tubes clean, and while there has been some tendency toward the dust bridging over on the superheater tubes, this is something that could be readily remedied by a change in the tube arrangement. It is interesting to note that in this boiler dust forms as an inverted V on the tops of the boiler tubes within half an hour after dusting, and that the increased

deposit after this half-hour period until the next dusting interval is almost imperceptible. This is unquestionably due to the high draft suction within the setting; that is, the high gas velocity actually has a scouring action on the tubes.

LEAKAGE

As in open-hearth work, it is important in cement waste-heat practice to reduce air leakage to a minimum with a view to increasing temperatures and boiler capacities and reducing the load on the fans. The main source of leakage in this class of work is at the end of the kilns where the rotary enters the dust chamber that ordinarily serves as the stack base. Experiment has shown that leakage at this point can be reduced to a negligible quantity by the use of a properly designed seal ring. The effect of the air leakage on the weight of gas that must be handled by the fan is indicated by the gas analysis. What can be done by way of reducing leakage and increasing gas temperatures is shown in Table 3, which gives

TABLE III—RESULTS OBTAINED BY REDUCING AIR LEAKAGE

		PLANT No. 1		PLANT No. 2		PLANT No. 3	
		Condi- tions as Found	Leak- age Re- duced	Condi- tions as Found	Leak- age Re- duced	Condi- tions as Found	Leak- age Re- duced
Gas Analysis	CO ₂ , per cent.	11.60	14.44	13.9	21.3	15.43	19.55
at	O ₂ , per cent.	11.85	10.4	4.4	7.99	2.87	
Stack Base	CO ₂ , per cent.	0.00	0.00	0.0	0.0	0.00	0.00
Gas temperature at stack-base,	deg. Fahr.	982	1242	1109	1480	1234	1360

results secured in the investigations of three different plants, the first figures showing conditions of operation as found and the second those after an intelligent effort has been made to better these conditions from the standpoint of a waste-heat boiler.

SAVINGS

As in most classes of waste-heat work, the greatest saving is in the value of power produced by the steam generated.

The measure of the efficiency of the cement plant is ordinarily the pounds of coal burned per barrel of cement, though presumably this should be corrected to a B.t.u. basis. The amount of coal per barrel depends upon the class of coal, the efficiency of the steam generators and prime movers, and the class of operation in the plant. The coal per barrel is divided into that actually burned in the kilns, which figure usually includes the amount required for drying the coal previous to pulverizing, and that burned in the power plant. In most plants an amount of coal, approximately $7\frac{1}{2}$ lb. per barrel, is used in drying the rock, and this should be included in the total. The installation of a waste-heat boiler does not of necessity reduce the coal per barrel of cement burned in the kiln, but it is obvious that any steam generated through the use of the waste gases from the kiln results in a reduction of the coal that must be burned in the power plant.

Possible savings through the utilization of the available heat in the gases leaving the kiln are indicated by the results secured at the Burt and Sandusky plants where boilers are not of the most highly developed waste-heat design, and to a much greater extent by the results obtained at the Louisville plant, where the boiler is more truly representative of such design.

Unfortunately, no figures are available from the Burt or Sandusky installations as to the coal burned

per barrel of cement in the power plants previous to the installation of waste-heat boilers, but the savings are seen in the proportion of the total steam generated by the waste-heat boilers.

At the Burt plant approximately 60 per cent of the total steam requirements is furnished by the four waste-heat boilers. The coal burned under the direct-fired boilers amounts to approximately 40 lb. per barrel of cement. On this basis, if the waste-heat boilers were not installed it would be necessary to burn 100 lb. of coal per barrel of cement in the power plant, a figure which is perhaps slightly high, as the 40 lb. per barrel now burned includes sufficient coal for banking two 300-hp. direct-fired boilers, in addition to the one actually operated. At Sandusky the waste-heat boilers develop approximately 65 per cent of the total power required. The coal burned in the direct-fired boilers is approximately 30 lb. per barrel of cement, on which basis it would be necessary to burn approximately 87 lb. per barrel in the power plant were no waste-heat boilers installed.

As stated, the possibilities of saving in this work through the use of waste-heat boilers are most clearly shown by the results secured at Louisville. Here the boiler is of the most modern design, and actual coal figures are available before and after the boiler installation. In addition to the two 150-ft. kilns attached to the waste-heat boiler, there are two kilns 8 ft. x 125 ft. There are also two kilns 7 ft. x 100 ft., although these are not at present operated. The coal burned per barrel of cement is some 15 lb. greater in the 125-ft. kilns than in the 150-ft. kilns. The plant is operated about nine months in the year.

In 1914, before the installation of the waste-heat boiler, the average coal consumption per barrel of cement for the total plant output was 191.2 lb., of which 99.5 lb. were burned in the kilns and 91.7 lb. in the power house.

The waste-heat boiler was installed in the early part of 1915 and was put into service May 12, although the plant was started in this year in March. The total coal consumption for the 1915 operation was 162.3 lb. per barrel of cement, of which 104.7 lb. were burned in the kilns and 57.6 lb. in the power house. The increase in the coal burned in the kilns per barrel over 1914 was due partly to a greater kiln output and partly to a larger proportion of the total production being from the smaller kilns. The decrease in coal burned in the power house is not representative of what could be secured for the reason that the figures are for the entire year's operation, while the boiler was not put into service for some two and one-half months after the plant was started.

For the months of March and April, 1916, the total coal consumption was 150.9 lb. per barrel, 104.05 lb. being burned in the kilns and 46.85 lb. in the power house. The decrease in the power-house consumption here below the 1915 figures is due to the fact that the waste-heat boiler was in operation continuously and because the large kilns were operated at a rate to give a greater capacity from the boiler than was secured in 1915.

For one week in May, 1916, conditions approached those that will be secured at this plant when the additional boiler, a duplicate of the present installation, is installed with the two 125-ft. kilns, and possibly with one 100-ft. kiln also connected. During this week the total coal consumption per barrel of cement was 123.5 lb., 94.7 lb. being burned in the kilns and 28.8 lb. in the power house. The reduction in the coal per barrel in the kilns was due to the fact that only the 150-ft. kilns were in operation. As in the case of the 1915 figures, the coal per barrel burned in the

power house does not represent what may be expected after the installation of the second waste-heat boiler, for, while the kilns were operating at a rate of 1145 bbl. each per day, or 2290 bbl. for the two kilns, due to the amount of clinker on hand, the grinding machinery was being operated at the rate of 3500 bbl. per day. With the second boiler in operation it would appear conservative to believe that the coal consumption in the power house for all kilns operating will be less than 15 lb.

For the purpose of figuring savings, assume that the figure 28.8 lb. per barrel will be burned in the power house. This would represent a saving of 62.9 lb. of coal per barrel of cement over the 1914 figures. For a production of 3500 bbl. per day, a conservative estimate for the Louisville plant, this would represent, for nine months' operation, some 29,000 tons per year. A boiler horsepower is valued at this plant at approximately \$25 a year, a figure which, in view of the operating year and the cost of coal, is conservative. On the basis of this value, the steam generated as shown in Table 2 is worth \$33,850 a year.

In addition to the saving represented by the power developed, there is an appreciable saving in the amount of dust reclaimed from the flue connecting the kiln or kilns to the boiler and from the boiler setting proper. This reclamation is ordinarily fed over again to the kilns with the raw material. That such a saving exists is apparent upon a visit to a cement plant equipped with waste-heat boilers, where it is seen that the deposit on surrounding property is appreciably less than in plants where no boilers are installed.

At the Burt plant, where the boilers are dusted once in 24 hours, approximately 2000 lb. of dust are reclaimed from each boiler setting per day and about 8000 lb. from the flues connecting two kilns to one boiler. This represents about 3 per cent of the total output of the kiln.

At the Sandusky plant, where the flue arrangement is not such as to give as good a settling action as at the Burt, about 4000 lb. are reclaimed from the boiler setting and connecting brickwork per day, or 1¼ per cent of the total output. At Sandusky, as stated, the boiler is not by-passed in any way during dusting intervals and an appreciable amount is blown up the stack.

At Louisville the flue connecting the two kilns to the boiler is long and is especially designed with the object of settling out as much dust as possible before the boiler is reached. This flue is equipped with hoppers at intervals along its length which are emptied each day and the material returned by conveyors to the kilns. The first boiler installed had settling pockets beneath the first pass and beneath the second and third passes, which are cleaned out by hand every few days. The second boiler installed is raised sufficiently to have hoppers beneath the various passes, the pockets to these hoppers being emptied as are the flue hoppers.

The amount of reclamation at the Louisville plant is such as to have reduced the raw material fed to the kilns per barrel of cement from 610 to 586 lb., a saving due to the dust collected of 3.9 per cent.

The above savings do not represent an increase over the amount reclaimed in plants where no boilers are installed, for at such plants there is a certain amount of material taken out of the collecting chambers which serve as stack bases. The figures given, however, probably represent a saving of at least 100 per cent more in the case of the kilns equipped with boilers over kilns not so equipped.

Copper Furnaces

The copper furnaces with which waste-heat boilers have been installed may be classed under two general heads: Smelting furnaces (matte furnaces) and re-

fining furnaces. In the United States the smelting furnaces are in localities more or less accessible to the copper mines, while the refining, with the exception of plants at Great Falls, Mont., and Tacoma, Wash., is done entirely on the Atlantic seaboard.

Smelting furnaces and refining furnaces are fundamentally the same in design, though for metallurgical reasons dimensions of the two classes and individual furnaces in the two classes are varied considerably.

Copper-smelting Furnaces. Because of the high temperature of the gases leaving copper-matte furnaces, it was but natural that the attention of engineers was early drawn to the utilization of such heat for steam generation.

At the time of the first installation such few waste-heat boilers as were in service in any class of work were single-pass boilers utilizing high-temperature gases and operating in such a way as to interfere in no manner with the working of the primary furnace. It is probably because of this fact that the effect of the boiler installation on furnace operation was apparently given no particular attention at the time of the purchase of the first boilers for this work.

The Anaconda Copper Mining Company purchased, in 1903, eight Stirling boilers, rated at the time at 375 hp. each, for installation with reverberatory smelting furnaces. The boilers were not equipped with firing fronts or grates, but were erected with the standard baffle arrangement for this type of boiler. As soon as the boilers were put into service it was found that the resistance to the gases through the boiler was so great as to affect appreciably the operation of the furnace, and the matter proved so serious that at one time the removal of the boilers was seriously contemplated. It was found, however, that by removing all baffles, the gases passed through the tubes without undue restriction, and that there was no interference with the operation of the smelting furnace.

The temperature of the gases entering the boiler averaged approximately 2200 deg. After the removal of the baffles, it was found that the temperature leaving the boiler was considerably in excess of 1000 deg., and in order to diminish this temperature and utilize a

greater proportion of the heat, a second boiler, rated at 300 hp., and also without baffles, was placed in the rear of the first boiler, that is, the two were set in tandem. The approximate arrangement is shown in Fig. 5. Under these conditions, for an average gas temperature of 2200 deg. at the entrance of the first boiler, the temperature when leaving the second boiler was found to vary from 620 to 720, the average being approximately 680 deg. It was determined by test that the first boiler developed 470 hp. and the second 100 hp., a total of 570 hp., or, on the basis of 10 sq. ft. per horsepower, 86 per cent of the rated capacity of the combined boilers. It is interesting to compare the results obtained from the second boiler, where the entering temperature was somewhat over 1000 deg., with the results secured from the modern waste-heat boiler in open-hearth steel practice, where the entering temperature is in certain installations the same. As against 33 per cent of nominal rating in the case of the copper-furnace waste-heat boiler, in steel plants, for a corresponding entering temperature, some 60 per cent of nominal rated capacity is developed with the modern boiler.

The flues in the Anaconda plant were so arranged that one pair of boilers could be cut out and all of the gases from two furnaces be passed through the next set. Under such conditions the temperature of the gases leaving the second boiler varied from 800 to 950 deg., the average being approximately 900 deg. The first boiler, with two furnaces connected, was found to develop 776 hp. and the second 194 hp., a total of 970 hp., or 143 per cent of the combined boilers. While this is considerably over rating for the amount of surface installed, it is interesting to compare the capacity and the exit-gas temperature with the results secured in utilizing waste gases from coke ovens (Table 5), where the temperatures of the gases entering the boiler are considerably lower than in copper-furnace work and the weight of gases approximately the same.

The high boiler-exit temperature with two furnaces connected to a pair of boilers, probably explains why double the amount of gas could be handled through the boilers without interfering with furnace operation.

The engineers of the Anaconda plant were more or

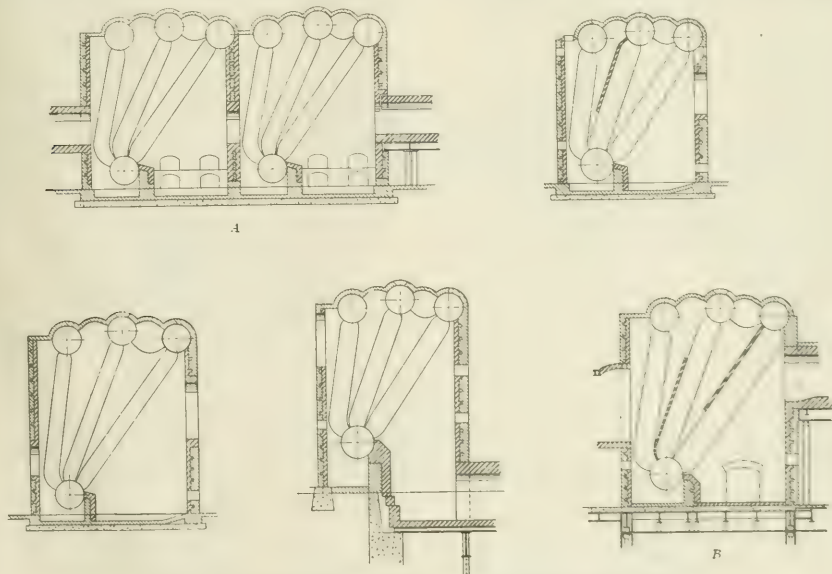


FIG. 5—TYPICAL WASTE-HEAT BOILERS FOR COPPER FURNACES

less directly connected with a number of copper-smelting plants, and naturally influenced largely the selection of the type of boiler to be used in this class of waste-heat work. The theory of such selection, based on the Anaconda results, apparently was the furnishing of ample gas-passage area. The operation of smelting in copper furnaces requires large quantities of coal. Because of the nature of the furnaces, air leakage was excessive. These factors led to enormous gas weights that had to be handled, and in the absence of mechanical means of draft, the furnishing of large gas-passage areas through the boilers was the sole means of keeping the draft loss within limits in which satisfactory furnace operation could be secured.

Acting on this theory, a great number of installations was made of boilers set in tandem, as at Anaconda, or single boilers of large cross-sectional area. Some of these single boilers were partially baffled, while others were entirely without baffles. In some few cases where single boilers were used, superheaters were placed in the outlet connection from the boiler to reduce exit temperatures and increase the combined capacity. Some typical settings of such boilers are shown in Fig. 5.

In 1905 or 1906 an installation was made at the Cananea Copper Company, which differed in general arrangement from what was the common practice at the time, as described above, and was a step in the direction of the more modern design of waste-heat boilers. Here, instead of using single boilers or boilers in tandem, three Stirling boilers rated at 314 hp. each were set in parallel, the gases from a single reverberatory being divided and passed simultaneously through all of the boilers. With this arrangement, each boiler was handling what might be considered a normal amount of gas at an entering temperature approaching that of coal-fired practice, and under such conditions baffle openings could approximate those standard in coal-fired work without excessive draft loss or interference with furnace operation.

The practice at the Cananea plant is described in a paper entitled experiments in Reverberatory Practice at Cananea, Mexico, presented in 1909 before The In-

stitute of Mining and Metallurgy, London, by Dr. L. D. Ricketts.

The success of this first installation at Cananea was such that two additional Stirling boilers were purchased in 1906. Three Aultman and Taylor boilers which were available were also reset for waste-heat work at this time, the seven boilers being connected to a common header flue receiving the gases from two reverberatory furnaces. The general arrangement of furnaces, flues, boilers, economizers and stack is shown in Fig. 6.

The operators and designers of this plant feel that because of the greater tendency of dust to lodge on horizontal than on the more nearly vertical tubes, the latter design of boiler is better suited to this particular work. This feeling is hardly borne out by experience in the cement industry, where the waste gases carry as much if not more dust than in copper-furnace practice. It seems probable that if the modern theory of high gas velocity were used in copper-furnace waste-heat boilers, there would be the same tendency for this velocity to keep the tubes "scoured" as was noted in the cement-kiln waste-heat boilers at Speeds, Ind.

Difficulties were experienced at Cananea through the clogging of the economizers with dust. This interfered seriously with the draft and hence with the furnace operation. Since mechanical draft was not used in this branch of waste-heat work, the designers of the plant omitted economizers in later installations.

The baffle openings in the Stirling boilers at the Cananea plant are approximately what are installed for standard coal-fired practice, and the baffling in the Aultman and Taylor boilers is standard. In some of the later installations where boilers were set in parallel the boilers were but partially baffled.

From 1906 to the present time there has been no radical change in the design of the boiler above described for utilizing the waste gases from copper-smelting furnaces. In the large number of installations made during this time all three arrangements—the single unit, the two units in series, and the two or more units in parallel—have been used, though perhaps the single large unit per furnace has been the most popular. The

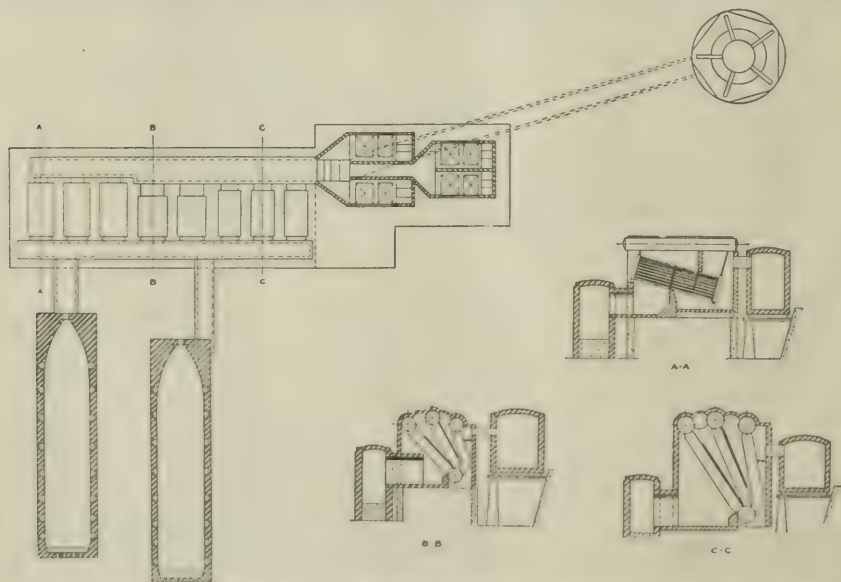


FIG. 6—GENERAL ARRANGEMENT OF FURNACES, FLUES, BOILERS, ECONOMIZERS, AND STACK FOR COPPER-FURNACE INSTALLATION

amount of baffling, that is, the gas-passage areas in the different installations, apparently has been governed largely by the individual ideas of the engineer in charge of the installation.

In the early installations it was common practice to install 12 sq. ft. of heating surface per horsepower to be developed. The tendency in later installations has been to increase rather than decrease this ratio, and many copper-plant engineers are advocating the installation of 20 sq. ft. per horsepower required from the class of boilers in general use for this work. A comparison of this allowance with that amount necessary in modern design of waste-heat boilers is of interest.

In the early installations in this work, serious fears were expressed that because of the great quantities of sulphur in the gases from smelting furnaces the life of the boiler would be short. These installations were carefully watched on this point over a considerable period, and as far as is known no trouble has arisen from this source; and there has been no action of the sulphur in the gases on the tubes except in such instances where, because of leaks or other causes, moisture has been present to form sulphuric acid. To minimize the possibility of moisture finding its way into the setting, it has been the general practice to use air for dusting tubes rather than steam.

It was noticed, however, in the early installations that there was a tendency for small lumps or nodules of solids to form on the surface of the tubes, particularly where the gases first impinged. These nodules, while they apparently had no action on the metal of the tubes, were very difficult to remove with an air jet, and for that reason provision was always made to give access to the heating surface so that this deposit could be removed with a wire brush. This last factor unquestionably had a considerable bearing on the omission of baffles for this work.

With smelting furnaces the only saving due to the utilization of waste gases is the steam generated. The amount of this saving may be roughly computed from the power developed as given in the figures in Table 4. That the copper industry considers that this saving warrants an investment in waste-heat boilers is perhaps best shown by the fact that there are to-day over 45,000 hp. of boilers set with copper-matte or smelting furnaces alone.

Copper-refining Furnaces.—As opposed to the continuous operation of a copper-smelting furnace, refining furnaces have a distinct cycle of operation, the gas weights available and gas temperatures varying

widely at different periods in this cycle. While at times the temperatures from refining furnaces are as high, or perhaps higher, than those from smelting furnaces, the average over a complete cycle of operation is considerably below the average for an equal period in the smelting furnace.

The temperatures from a matte furnace average approximately 2000 to 2200 deg. In the case of the refining furnace these temperatures, over a complete cycle, will vary from about 400 deg. during charging to something over 2000 deg. while melting, and the average for such a cycle, some 30 hr., will be approximately 1400 deg. The length of the cycle and the temperature of the gas available for different periods will vary with the size and operation of the furnace. As an indication of the variation in results to be expected at different periods of the cycle, some figures on boiler capacities from a 400,000-lb. furnace may be of interest. These figures represent 30 hr. of a 33½-hr. complete cycle. The average horsepower developed during this period was approximately 320.

Period	Duration, Average.	
	Hr.	Hp.
Charging	4	36
Melting	16	450
Poling	2	277
Between poling and tapping	1	277
Pouring	5	266

While the writer is not sure of the exact date of installation of the first waste-heat boiler with copper-refining furnaces, he believes that the Baltimore Smelting and Rolling Company (American Smelting and Refining Company) were the pioneers in this field. This company installed two Stirling boilers rated at 335 hp. each in 1907. These boilers, as in the case of the first installations with matte furnaces, were furnished with standard baffles. Because of interference with furnace operation, it was found necessary to increase the baffle openings to more than twice the standard. This company has installed over 3500 hp. for additional furnaces.

Other refining companies followed the Baltimore Smelting and Rolling Company in the utilization of this class of waste heat, and the writer is familiar with over 11,000 hp. of boilers in this class of work.

As far as is known, there has been but one attempt made to utilize the theory of high gas velocity in the production of steam from copper-furnace waste gases. This was done in 1914 at the plant of the Raritan Copper Company, Perth Amboy, N. J. This company purchased three 450-hp. Babcock & Wilcox waste-heat boilers of the general design described in connection with open-hearth steel furnace practice, a design necessitating the use of an induced-draft fan for the proper operation of the primary furnace. The Raritan Copper Company has also 2600 hp. of Stirling boilers in which the principle of high gas velocity is not used, and results from the two designs are available. These results are given in Table 4.

In Test 3 the temperature of the gases leaving the furnace was 2190 deg., in the main flue, 1928, and entering the boiler, 1621 deg. This loss was due to leakage and radiation.

It will be noted from a comparison of the results of Tests 4 and 5 that the gas weight passing through the Babcock & Wilcox boiler is 42 per cent less than the weight passing through the Stirling boiler. While the entering gas temperature is some 120 deg. higher in the case of the Babcock & Wilcox boiler, the exit temperature is approximately 100 deg. lower. In other words, the gas temperature drop through the Babcock & Wilcox boiler is approximately 200 deg. greater than through the Stirling boiler for a gas weight of 20,000 lb. less.

TABLE IV—RESULTS OF TESTS OF WASTE-HEAT BOILERS WITH COPPER FURNACES

Test Number	1	2	3	4	5
Plant	Anaconda Copper Mining Co.	Inspira-Copper Co.	Ariz	Raritan Copper Co.	
Location	Anaconda, Mont.	Miami	Perth Amboy, N. J.		
Furnace	Matte	Matte	Matte	Refining	Refining
Boiler	Stirling	Stirling	Stirling	B & W	B & W
Heating surface, sq. ft.	7,500	7,500	14,068	3,940	4,490
Gas weight, lb. per hr.	49,352	98,400	160,010	70,100	30,400
Gas per hr. per sq. ft. of h.s., lb.	6.66	13.13	11.38	17.79	11.23
Temperatures:					
Gas entering boiler, deg. Fahr.	2,200	2,200	1,621	1,429	1,547
Gas leaving boiler, deg. Fahr.	630 ¹	800 ²	626	670	684
Drop in temp., deg. Fahr.	1,520	1,310	925	759	963
Draft at boiler damper, in.			0.80	1.15	2.28
Draft at boiler inlet, in.			0.44	0.56	0.60
Draft loss, in.			0.36	0.59	1.68
Horsepower developed	570 ³	970 ⁴	1,111	401	365
Per cent of rated capacity	76	129	78.3	103	81.4
Approximate transfer rate (R)	2.3	3.6	3.4	4.9	4.0

¹Two boilers in tandem, approximately as A, Fig. 5.

²Gas from one furnace passing through two boilers.

³Range, 620 to 720 deg.

⁴Front boiler, 470 h.p.; rear boiler, 100 h.p.

⁵Gas from two furnaces passing through two boilers.

⁶Range, 800 to 950 deg.

⁷Front boiler, 776 h.p.; rear boiler, 194 h.p.

⁸Two single boilers, approximately as B, Fig. 5. Boilers equipped with superheaters in exit flues. Horsepower includes super-heat; exit temperatures are after leaving superheaters.

As was shown in the discussion of some of the results secured with open-hearth furnaces (Table 1), it would be necessary, before a direct comparison would be possible, that the gas weight per square foot of heating surface and the entering-gas temperature should be the same. On this basis, the total gas weight passing through the boiler of Test 5, for comparable results, would be approximately 80,000 lb. per hour, and with an entering-gas temperature as in Test 4, the boiler would develop 495 hp., or 11 per cent above its rated capacity. This would indicate a gain of 11 per cent in gross power developed, in favor of the more modern waste-heat boiler.

The results on such a basis are, as stated, in favor of the Babcock & Wilcox boiler, though they are not as much better as we would ordinarily expect. This is due to the fact that the fan installation is not entirely suited to the conditions which must be met. Furthermore, as a commercial proposition the fans in the present installation are motor-driven, and the power required for such drive is directly chargeable to the boiler; whereas, if a turbine drive were employed, much of the heat in the steam used for such drive could be reclaimed in feed-water heaters.

As in all waste-heat work, the power developed from these waste gases represents a very considerable saving in coal that would otherwise have to be burned under direct-fired boilers. Unlike copper matte furnaces, however, the value of this power does not represent the greatest saving through the use of waste-heat boilers. The boilers connected to copper-refining furnaces make ideal "dust catchers," and the value of the copper so reclaimed is a highly important item. The writer is not at liberty to give actual figures of savings from this source, but can state authoritatively that in one plant the value of the dust reclaimed from the boiler setting is over one and one-half times the value to the owners of the steam generated. The values of this steam may be approximated from the boiler capacities given in Table 4.

(To be concluded)

Metallurgical Clay Goods.—The Denver Fire Clay Co., Denver, Col., has issued bulletin No. 100, describing muffles, crucibles and scorifiers.

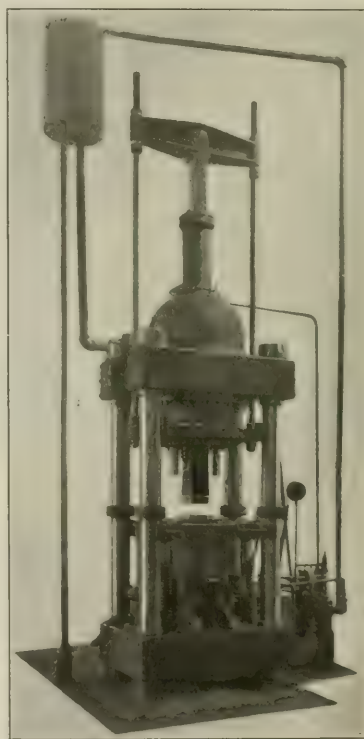
"Fuel Oil Driven Compressors" is the title of a new bulletin issued by the Chicago Pneumatic Tool Co., Chicago, Ill. The bulletin describes air compressors operating on various low grade oils.

Metallurgical Society of Missouri School of Mines.—The Metallurgical Society effected a permanent organization Nov. 14, 1916. The following officers were elected: T. P. F. Walsh, president; H. A. Horner, vice-president, and C. L. Epperson, secretary-treasurer. An executive committee, consisting of Professors Mann and Clayton, Horner, Epperson and T. P. F. Walsh, chairman, was elected to draft a constitution and make all necessary arrangements for a successful year. The society, meeting every two weeks, intends to devote its time to metallurgy, ore dressing and chemistry.

Labor Laws of Pennsylvania.—The monthly bulletin of the Department of Labor and Industry of the State of Pennsylvania for September contains a compilation of all essential portions of Pennsylvania labor laws that should be known by all employers, employees, employment agents and all those concerned with employment in any way. Mr. John Price Jackson is commissioner of the Department of Labor and Industry, his office being in Harrisburg.

Manufacturing Commercial Salt Blocks by Hydraulic Pressure

Manufacturers and producers of both evaporated and rock salt have long felt the need of efficient and profitable methods of producing commercial salt blocks of uniform size, weight and density for the prevention of waste and for the convenience of handling, shipping, etc. Both evaporated and rock salt are secured from the same source, evaporated salt being originally rock salt. Rock salt manufacturers secure their material in the same manner as coal is mined, a shaft being sunk and the salt removed in lump form. Similarly it passes over screens for obtaining different grades for various purposes. Evaporated salt is obtained by drilling a hole into the rock salt bed and casing the hole in the same manner as producers of petroleum and natural gas case their oil and gas wells. Tubes are sunk into the casing and the latter sealed at the top. Water is then pumped through the casing down



750-TON INVERTED SALT BLOCK PRESS (EJECTING SIDE).

into the salt bed for dissolving the salt, the resulting brine being forced out and evaporated.

The natural block of rock salt as it comes from the mine, is used quite extensively for stock feeding purposes because it is slow to evaporate and does not easily break up. The crude blocks are thrown into the field and left for the stock to lick at their will. However, with all of the apparent advantages of rock salt there is considerable waste in mining and handling the natural block. When removing the natural rock salt in large lumps and breaking it up in many smaller pieces and screening it, much loose salt results which

is unsuitable for commercial purposes in its natural state. There being no way to dispose of this waste loose salt, the manufacturers have left it to accumulate in piles outside of the mine or in some instances have gone to the expense of hauling it back into the mines.

When this waste salt is left in piles outside of the mine it becomes a menace to surrounding territory, because the rains wash the brine out over the land and down into the streams. This, of course, proves unsatisfactory to the farmers and owners of land surrounding the mine, because it destroys the producing value of the farm land and impairs the natural value of the fresh water streams. So much of a menace had this situation become in rock salt manufacturing centers that it attracted the attention of the Federal Government as well as individuals located in the affected territory. Thought was then turned to an efficient and profitable method of disposing of this waste and by extensive experiments it was found that solid salt blocks of uniform size, density and weight could be easily made from loose salt if placed under heavy pressure, the resulting block having no tendency to disintegrate from the effects of the weather in the open field. The only action of water is to very slowly wear away the block from the outside. When the block becomes wet and is again dried it appears to be much harder than before the moisture came in contact with it.

Evaporated salt heretofore little used for stock feeding, can be made into blocks by this method. Blocks made by the hydraulic press have proven equally satisfactory whether they are made from evaporated salt or rock salt.

The Hydraulic Press Manufacturing Co., Mount Gilead, Ohio, has developed and patented a design of hydraulic press which will produce a satisfactory salt block of uniform size and density. The accompanying photograph shows this press. It is built in two sizes, one having a pressure capacity of 1000 tons and the other 750 tons.

The salt is compressed in a mold into a compact block of uniform density approximately $8\frac{1}{4}$ in. square by 12 in. high. The salt block is removed from the mold by hydraulic pressure. The block is then removed for shipment or storage. The press is provided with a surge tank, the base of which is located higher than the main cylinder. By a simple movement of the valve lever the plunger drops to the salt in the mold and the main cylinder is filled with fluid by suction caused by the lowering of the ram as well as by the gravity of the fluid. Thus the first stroke of the pump initiates the pressure upon the salt. After the block forming operation is completed the main ram is returned by means of the auxiliary ram located at the extreme top of the press. This action returns the fluid to the surge tank. The operations of the press are controlled by hydraulic valves, the levers of which are conveniently located for the operator. The press is operated from an independent steam, belt or motor driven pump or from an accumulator system.

Some of the advantages claimed for the artificial blocks are:

That the pressed block is more shapely and does not have the rough edges and sharp shale inclusions, which are the most objectionable features of the natural block, and therefore, does not cut the mouths of the stock as the natural block does; that it has a much greater density than the natural block and will, therefore, last longer and resist the action of the weather longer in the open field; that the blocks are all uniform in size and shape; therefore, they pack to a bet-

ter advantage in the car and are much more easily handled as they all weigh exactly the same; and that it is possible in manufacturing this artificial block to add sulphur or other ingredients, thus making a medicated block.

A Machine for Testing Metal Sheets

Since none of the customary metal tests, such as the Brinell or scleroscope test, can be satisfactorily applied to metal sheet, Mr. A. M. Erichsen, a Norwegian metallurgical engineer, has designed an ingenious apparatus which permits convenient and accurate tests of all kinds of metal sheets from 0.1 to 5 mm. thickness; by using special attachments, the machine can also be successfully used for testing wires up to 6 mm. diameter, cartridge cups, metal tubing, and to determine the "spring" qualities of metal ribbons.

In the practical application of metal sheets, mostly in

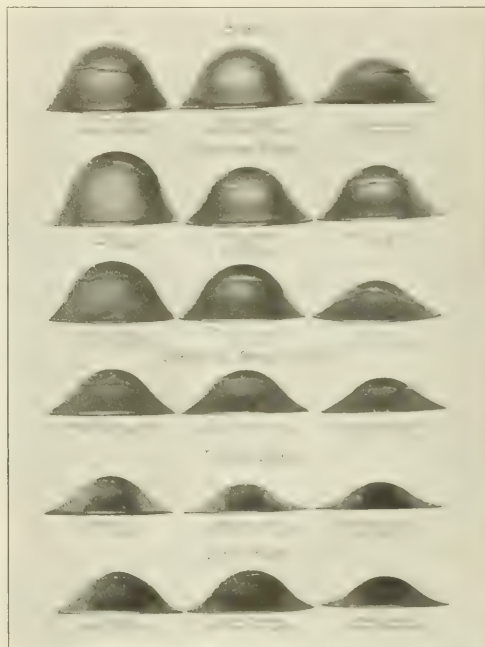


FIG. 1—RESULTS OBTAINED WITH TESTING MACHINE

drawing, stamping, or compressing operations, the ductility and tenacity of the material is of more importance than the ultimate tensile strength. The Erichsen method determines the actual "workability" of the metal sheets: a test piece is placed between a die and a holder, and a tool having a rounded end is moved gradually forward under the influence of a ram actuated by a micrometer screw and hand wheel, until the fracture occurs. The test piece is under the permanent observation of the operator through a mirror, so that the point of fracture can be ascertained with great accuracy. The "drawing value" of the material can be read off directly on the apparatus and is the basis on which the quality of the metal sheet is determined. Great tenacity combined with high tensile strength will give the best press value, which latter, however, is neither proportional to the effective modulus of elongation nor to the ultimate tensile strength. As all apparatus man-

ufactured under the Erichsen patents are made from the same precision gages and are adjusted in the same manner, the results obtained permit accurate comparisons, so that standards can be established for use in specifications of manufacturers and purchasers of metal sheets.

The illustration shows a cross-section of the machine,

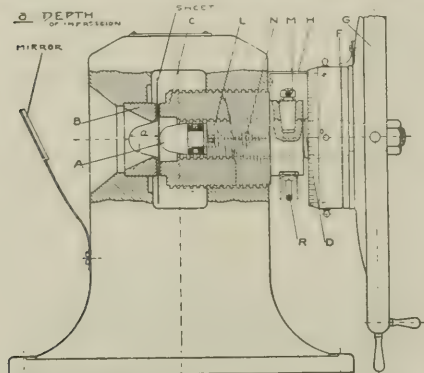


FIG. 2—CONSTRUCTION OF TESTING MACHINE

with the direct-reading scale and observation mirror. In testing a piece of sheet metal it is first placed between the die ring *B* and the holder *C* and the thickness read off the movable collar *D*. Before doing this the latter must be set at zero, which is done by turning it until the spring *F* snaps into a small hole in the collar. After determining the thickness the machine is again set at zero and the wheel turned until the piece cracks. Knowing the thickness and the amount the wheel had to be turned to crack the piece furnishes values with which to compare the piece with certain standard pieces.

Mr. Erichsen, who has introduced the machine extensively in Europe, was recently in this country and granted the sole license under his American patents to Mr. Herman A. Holz of 50 Church Street, New York, who is manufacturing the machine in this country.

Current News and Notes

Government Potash Plant for California.—In August, 1916, the Congress of the United States appropriated \$175,000 for the investigation of sources of potash within the United States. This appropriation was designed to make possible the continuation on a large scale of the work inaugurated and carried on by the Bureau of Soils of the U. S. Department of Agriculture. As a result of this work, and of the operations to date of the various commercial organizations engaged in the extraction of potash from kelp on the Pacific Coast, it appeared to the officials of the Department of Agriculture that the giant kelps of the Pacific Coast represented the largest and most immediately available source of potash in the country. Accordingly the Secretary of Agriculture has authorized the construction at some point on the coast of Southern California of a plant to be designed and operated to demonstrate on a commercial scale the various processes of extracting potash and by-products from kelp. This work will be carried on by the Bureau of Soils under the personal supervision of J. W. Turrentine. The bureau proposes to proceed at once with the execution of its plans.

New Chicago Laboratory.—Dr. Rudolph R. Rosenbaum, formerly of the Central Commercial Co., Chi-

cago, has opened an up-to-date laboratory at 53 West Jackson Boulevard, Chicago, which will be known as the Western Chemical Laboratories. While general organic analysis and research will be carried on, the organization is especially equipped to design petroleum refineries, investigate processes and industrial propositions and do analytical work on petroleum.

Dyestuffs Census Now Available.—The census of dyestuffs, compiled by Dr. Thomas H. Norton of the Bureau of Foreign and Domestic Commerce, is now available from the bureau in its revised form. The efforts of the importers to prevent the publication of the census in its original form were successful, but an effort is expected to be made by the dye-makers and consumers in this country to have Congress take some action in the matter and have the original census published, showing the quantities and values of each dye in the groups and also the key to the makers.

The Utah Chemical Company has been making regular shipments of potash and Glauber's salts from its Saltair, Utah, plant. The plant is owned by the Southern Cotton Oil Co., which uses the Glauber's salts as a fertilizer for cotton growing.

Safety in Steel Mills.—The Bureau of Mines has issued a technical paper (No. 102) dealing with "Health Conservation at Steel Mills." The author is Dr. J. A. Watkins formerly assistant surgeon of the U. S. Public Health Service and the information should prove interesting and helpful to all interested in safety work.

Water Controlling Apparatus.—The Rodney Hunt Machine Co., Orange, Mass., has issued catalog 30, describing flumes, penstocks, stand pipes, gates, valves, etc., for controlling water.

Personal

Mr. Arthur P. Allen has left the Calumet & Hecla Co., and is now with the Highland Mining Co., Ashcroft, British Columbia.

Mr. Frederick K. Brunton has resigned his position with the American Smelting & Refining Co., Garfield, Utah, and is now assistant superintendent of the Consolidated Arizona Smelting Co., Humboldt, Ariz.

Mr. Frank R. Corwin has resigned as assistant superintendent of the Consolidated Arizona Smelting Company, to become assistant superintendent of the International Smelting Co., at Miami, Ariz.

Mr. C. R. Delaney of Hanover, Pa., is chief chemist of the new plant of H. E. Young & Co., Inc., at Charlottesville, Va.

Mr. W. E. Greenough has resigned his position as manager of the Marsh Mining Co., Idaho, and has opened offices in the Old National Bank Building, Spokane, Wash., as an independent consulting engineer.

Mr. Henry D. Hibbard of Plainfield, N. J., has returned from a trip to Norway and Sweden.

Mr. J. R. M. Klotz, manager of the Newport Chemical Works of Carrollville, Wis., and in charge of the New York office at 32 Liberty Street, was married on Dec. 6 to Miss Margaret Sliger of Helena, Ark. Mr. Klotz is secretary of the Chemists' Club and was for many years with the Barrett Company.

Mr. G. Komorowski, metallurgical engineer, recently arrived in New York from France, represents the firm controlling the Girod electric furnace, and his headquarters in New York are with the American agents for the furnace, C. W. Leavitt & Co., 30 Church Street.

Mr. C. J. Ramsburg, vice-president of the H. Koppers Company and Pittsburgh By-Product Coking

Company, Pittsburgh, Pa., will lecture before the Franklin Institute of Philadelphia, on Feb. 1, 1917, on the "By-Product Coking Industry."

Mr. W. C. Stevens has been appointed general sales manager of the Cutler-Hammer Mfg. Co. of Milwaukee. He has been connected with the company ever since graduating from Cornell, about ten years ago. The last three years he has been in charge of the New York office. He has devoted much of his time to sales and installation work in connection with controllers for steel plants and unloading plants, including blast furnace skip hoists, ore bridges, coal bridges, coal dumpers, car conveyors and other equipment used in the steel and iron industry. He will remove from the New York office to the Milwaukee office about Jan. 1. Mr. T. D. Montgomery has been appointed to the position made vacant by the promotion of Mr. Stevens.

Obituary

Mr. Samuel James, manager of the Northport Smelting and Refining Company of Northport, Wash., died suddenly Saturday, Nov. 25. Mr. R. W. Marston will assume the duties of acting manager until further notice.

Book Reviews

The Journal of the Institute of Metals. Vol. XV. Edited by G. Shaw Scott. 390 pages. Price, 21s. net. London: The Institute of Metals.

Papers and discussion on corrosion form the predominant feature of this volume of the Institute of Metals, including the Third Report to the Corrosion Committee. There are two papers on aluminum and its alloys, one on nickel-silver (formerly known in England as German silver) and one on electric furnaces in non-ferrous metallurgy. The frontispiece is a portrait of Sir George Beilby, the new president of the Institute of Metals.

Galvanizing and Tinning. By W. T. Flanders, with the assistance of seven specialists. Octavo (14 x 22 cm.), 350 pages, 134 illustrations; price, \$3.50. New York: David Williams Company.

The author, connected with the Malleable Iron Fittings Company, described in articles in the *Metal Worker* and *The Iron Age* the design and operation of plants for hot galvanizing and tinning, drawing upon his thirty-five years of experience as builder and manager of such plants. These articles form the nucleus of the book, to which are added three chapters on electro-galvanizing and several chapters on sherardizing. Messrs. John Calder, R. D. Foster, C. J. Kirk, A. F. Schoen, Louis Schulte, W. G. Stratton and S. Trood co-operated in these chapters, but where and to what extent is not itemized in the text. The treatment throughout is in the style and quality of the technical trade paper, being intended for practical usefulness to those operating and managing plants rather than for students of the why and wherefore of operations. It is a welcome book, containing a great deal of information not to be found elsewhere.

A System of Physical Chemistry. Vol. I, Kinetic Theory; Vol. II, Thermo-dynamics and Statistical Mechanics. By Wm. C. McC. Lewis. 12 by 18½ cm., 523 and 552 pages; price, \$2.50 net per volume. New York and London: Longmans, Green & Co.

This is intended as a text-book for persons already knowing elementary physics and chemistry, and preferably also familiar with the broad outlines or principles of physical chemistry. It is therefore meant to be a comprehensive treatise on physical chemistry; inspection shows it to be systematic in plan and rea-

sonably complete in detail. A strange oversight in the discussion of the additive properties of salts in solution is the omission of any reference to the additive nature of the energies of chemical combination or formation of the salts from their constituents, when measured to dilute solutions. But, aside from this, the work may be taken as a complete and clear presentation of all branches of physical chemistry.

MARKET REPORTS

The Iron and Steel Market

Shipments of Lake Superior ore down the lakes in November reached the remarkable total, for a November, of 5,715,452 tons. The vessels carried less than half the usual quantity of grain, devoting their attention more to ore. The lake movement to December 1 totals 63,648,298 tons, which, with 1,000,000 tons estimated for December and 1,500,000 tons for all-rail movement, should make the year's total a trifle more than 66,000,000 tons, against a former record of 49,947,116 tons, made in 1913. Before the navigation season opened some ore interests insisted that there would be a shortage of ore as the lake fleet would be unable to transport more than 60,000,000 tons at the outside. Various estimates were made some months ago as to the amount of ore that should be moved to ensure the furnaces operating without difficulty until the opening of navigation in 1917, the computations usually showing 62,000,000 to 64,000,000 tons. The furnaces will have no difficulty as to ore this winter, but have already experienced a shortage in coke, not sufficient to decrease the country's pig-iron production by an appreciable amount, but sufficient to produce a market for Connellsville furnace coke for spot shipment of \$7 to \$8 per net ton, when most of the existing contracts, to expire Dec. 31, are at from \$2.15 to \$2.75.

Iron and steel exports in October, returned by weight, totaled 610,096 gross tons, against 643,767 tons in September, the record tonnage for a month. Despite the decrease from September, the October exports were 26 per cent in excess of the average for the nine preceding months of the year, that average having been 484,555 tons per month. The largeness of the exports in September and October was due chiefly to there having been great increase in exports of pig iron and unfinished steel, pig iron exported in October amounting to 101,756 tons, while exports of billets, blooms, ingots, sheet bars, etc., amounted to 162,679 tons in October.

THE SCARCITY OF STEEL

References to a "scarcity of steel" first appeared in September, 1915, by which time the steel mills had reached a point of operating at capacity. If the condition then was of a scarcity the condition now is an extreme famine. Buyers for both domestic and foreign account are scouring the country for unfinished steel of all descriptions and only occasionally do they find any steel at all. Offerings are usually of tonnages much smaller than are required for.

There was a time, perhaps, when the scarcity of unfinished steel in the market was to be attributed to the mills being unwilling to sell unfinished steel to buyers not their regular customers because they desired to retain the steel to produce finished material for their regular customers. Such a principle no longer obtains as the mills are not making satisfactory deliveries of finished steel to their customers and a little more or less does not matter. Some of the finished steel products represent a larger profit than would be obtained by selling unfinished steel in the

market, but there are some commodities in which this is not the case. As illustrating one of the vagaries of the market, wire nails as recently advanced are \$3 per keg, base, or \$60 per net ton. For soft steel rods \$65 to \$70 would be bid, but practically none are offered. If the mill can spare rods at all it makes them in high carbon, at a slight increase in cost, and then obtains about \$90.

STEEL PRICES ADVANCING

The general trend of the finished steel market is sharply upward. There can be no regularity in the movement as prices proceed by large intervals. On Dec. 4 wrought iron and steel pipe and line pipe were advanced two points or about \$4 a net ton. Within a few days black, blue annealed and galvanized sheets advanced \$5 a ton. Bars, plates and shapes have not advanced since the advance of Nov. 21, which was \$5 a ton on plates and \$4 on bars and shapes. An advance of \$5 a ton is predicted to occur before the end of the month.

Advances in finished steel prices are to be attributed, in general, to the increasing value of steel as steel, and thus there is generally a coherence between price advances in the different commodities, but there are various exceptions, plates being the most striking. The plate mill and slabbing mill capacity of the country is altogether insufficient for this abnormal demand, and plates even for the most forward delivery are about \$10 a ton higher than the related commodities, bars and structural shapes, but while plates at 3.50c. are high there have been bids of 5c. for ship plates for delivery during the first half of 1917.

As suggestive of the vagaries in the market it may be noted that for several weeks, until early in December, railroad spikes were 2.65c., Pittsburgh, and 2.75c., Chicago. They had gotten into a rut and meanwhile steel bars had advanced to 2.90c., Pittsburgh, although the cost of conversion used to be figured at about \$9 a net ton and is presumably higher now. Suddenly, spikes started to advance and in a few days were 3.40c., Pittsburgh, and 3.50c., Chicago, an advance of \$15 a net ton.

UNFINISHED STEEL

Soft steel billets, Bessemer or open-hearth, are quoted at \$55 to \$57 as representing approximately the market, though rarely is the market actually shown by transactions. For export they would readily bring \$55, Pittsburgh or Youngstown, but bids as high as \$60 are not yet made. Soft steel rods are about \$70, with high carbon at about \$90, and forging billets are in the neighborhood of \$75. It is believed that nearly all the shell steel billets to be bought for 1917 are already under cover, the total business in shell steel for the year being in the neighborhood of 2,000,000 or 4,000,000 tons. Shell steel billet discards readily bring \$35.

PIG IRON

Pig iron continues to advance at the average rate of about 20 cents per business day, the rate mentioned in last report, but the rate seems to have increased a trifle. Bessemer iron is at least \$35, Valley furnaces, while basic has been in the neighborhood of \$30. The advance is probably in part psychological, sellers finding it easy to secure advanced prices while buyers are moved to purchase by seeing the market advance so rapidly. There is talk of an actual scarcity of pig iron, but until the prompt market is definitely higher than the forward market judgment may be suspended. That there is fear of a serious shortage of pig iron is beyond question. The production cannot be materially increased, while it may de-

crease through shortage of coke, while the consumptive capacity is increasing by constant additions to the open-hearth steel making capacity of the country.

Non-Ferrous Metal Market

Dec. 8.—Copper continues in its strong position chiefly owing to the ability of the producers to sell far into the future, making supplies scarce. Tin is less active in spite of small arrivals, lead is very strong, while spelter is somewhat weaker. The rise in silver is expected to bring about a record production.

Copper.—Copper has advanced further and electrolytic is now quoted at 35.25 bid to 35.75 asked for prompt delivery. Lake is quoted at 34.50 to 35.00 for prompt delivery. Buying eased off a little during the last few days in November, but since then inquiries have been resumed with a rush. Exports during November amounted to only 21,433 tons, but this is explained by the scarcity of freight room on outgoing steamships. Our exports this year will be higher than in 1915, but will not be as high as in 1914 and 1913, when 360,229 and 382,810 tons respectively were exported. Many large domestic consumers have covered their requirements for nearly all of 1917, and it is this buying far into the future which places the producers in such a strong position. Copper may go higher, but with our enormous production there does not seem to be any good reason for it, although domestic demand at present is enormous. Casting copper is very scarce, with sellers asking 33.00 to 33.50 cents for prompt delivery.

Tin.—Straits tin has declined from 45.50 on Nov. 27 to 43.80 cents on Dec. 7. Buying has been very dull in spite of the fact that deliveries in November were far below normal and there is no change in England's attitude in issuing permits. November arrivals totaled 2230 tons, to which must be added our home production at Perth Amboy, N. J., of about 400 tons. There is not so much Chinese tin coming in as formerly, and the attitude of buyers in holding off is hard to understand.

Lead.—The trust price of lead was advanced to 7.50 cents New York on Dec. 5. It is predicted that lead will go to 8 cents, and independents are already asking 7.50 to 8.00 cents. Domestic demand outside of war supply needs is the chief factor influencing the market at the present time.

Spelter.—Spelter has weakened considerably and eased off from 13.30 asked on Dec. 1 to 12.17½ asked on Dec. 7. The chief factor in the decline has been the eagerness of dealers to sell while the demand continues about the same.

Other Metals.—Antimony is quiet, with Chinese and Japanese quoted at 14.37½. Aluminum is unchanged in the open market and brings 63.00 to 65.00 cents. Silver is up to 75%, and, needless to say, production will be pushed to the limit. Platinum continues almost prohibitive at \$105.00 per oz. Magnesium is unchanged at \$3.50 per lb., electrolytic nickel is 50.00 cents, quick-silver \$80.00 per flask and tungsten ore \$18.00 per unit.

General Chemicals

WHOLESALE PRICES IN NEW YORK MARKET DECEMBER 7.

Acetic, 40 deg.	lb.	\$0.22½	\$0.23
Acid, Acetic, 28 per cent.	100 lb.	3.50	3.65
Acetic, 50 per cent.	100 lb.	7.00	7.15
Acetic, Glacial, 99½ per cent., carbide	lb.	.25	.30
Boric, crystals	lb.	.12½	.13½
Chloro, crystals	lb.	.65	.67
Hydrochloric, commercial, 18 deg.	100 lb.	1.75	2.00
Hydrochloric, 20 deg.	100 lb.	2.00	2.25
Hydrochloric, C. P., conc., 22 deg.	100 lb.	2.25	2.50
Hydrofluoric, 30 per cent., in barrels	lb.	.05	.06½
Sulfur, 36 (40) deg.	lb.	.06½	.06½
Sulfur, 47 (40) deg.	lb.	.07	.07½
Sulfuric, 20 deg.	lb.	.50	.55

Phosphoric, 85 per cent.....	lb.	29½	30
Phosphoric, 90 per cent.....	lb.	30	31
Pyrogallol, sublimed.....	lb.	3.25	3.45
Sulphuric, 60 deg.....	100 lb.	1.50	1.75
Sulphuric, 66 deg.....	100 lb.	1.75	2.00
Sulphuric, oleum (fuming).....	100 lb.	1.75	2.00
Tar, U. S. P. bulk.....	lb.	.90	1.05
Tartrate, crystals.....	lb.	.65	.70
Alcohol, grain, 188 proof.....	gal.	2.75	2.75
Wood, 95 per cent.....	gal.	.95	.97
Denatured, 180 proof.....	gal.	.65	.67
Alum, ammoniac, lump.....	lb.	.04	.04½
Chromic.....	lb.	.25	.26
Potash.....	lb.	.03½	.03½
Aluminum sulphate, technical.....	lb.	.03½	.04
Aluminum sulphate, iron free.....	lb.	.05	.05½
Ammonia aqua, 26 deg, carboys.....	lb.	.06	.06½
Ammonium carbonate.....	lb.	.10	.10½
Ammonium sulphate, domestic.....	lb.	.04	.04½
Amyl acetate.....	gal.	4.50	4.80
Antimony salt, 75 per cent.....	lb.	..	..
Antimony sale, 65 per cent.....	lb.	..	..
Antimony salt, 47 per cent.....	lb.	..	..
Argols.....	lb.	.08	.09
Arsenic, white.....	lb.	.06½	.07
Barium chloride.....	ton	110.00	115.00
Barium nitrate.....	lb.	13½	14
Barium peroxide.....	lb.	..	.36
Bleaching powder, 35 per cent.....	lb.	.04½	.07½
Borax, crystals, sacks.....	lb.	.08	.08
Brimstone.....	28.00	29.00	..
Bromine, technical.....	lb.	1.40	1.45
Calcium acetate, crude.....	100 lb.	3.50	3.55
Calcium carbide.....	ton	73.00	75.00
Calcium chloride, 70-75 p. c. fused, lump.....	ton	23.00	24.00
Calcium chloride, granulated.....	ton	23.00	24.00
Calcium peroxide.....	lb.	1.50	1.50
Calcium sulphate.....	lb.	.10	.10
Carbon bisulphide.....	lb.	.06	.07
Carbon tetrachloride, drums.....	lb.	18½	.17
Caustic potash.....	lb.	.78	.80
Caustic soda, 76 per cent.....	lb.	.05	.05½
Chlorine, liquid.....	100 lb.	1.25	1.50
Copper carbonate.....	lb.	.45	..
Copper chloride (cupric).....	lb.	.55	.60
Copper cyanide.....	lb.	..	.65
Copper sulphate, carloads.....	lb.	.14	..
Cream of tartar, crystals.....	lb.	.39½	.41
Epsom salt, bags, tech.....	100 lb.	1.75	2.00
Formaldehyde, 40 per cent.....	ton	.50	.75
Glauber's salt.....	100 lb.	1.00	1.10
Glycerine, bulk.....	lb.	.22½	.23
Hydrogen peroxide, 1-lb. bottles.....	gross	18.00	..
Iodine, resublimed.....	lb.	4.25	..
Iron oxide.....	lb.	.13	.15
Iron sulphide.....	lb.	.04	.05
Lead acetate, white crystals.....	lb.	.13	.13½
Lead arsenate, pulped.....	lb.	.08	.09
Lead nitrate.....	lb.	..	.07½
Lead oxide, litharge, American.....	lb.	.21	.23
Magnesium carbonate.....	lb.	.11	.11½
Nickel salt, single.....	lb.	.08	.08½
Nickel sale, double.....	lb.	..	..
Phosphorus pentachloride.....	lb.	..	1.00
Phosphorus, red.....	lb.	..	.50
Phosphorus, yellow.....	lb.	.40	.42
Potassium bichromate.....	lb.	1.35	1.36
Potassium bromate, ground.....	lb.	.40	..
Potassium carbonate, calcined, 80-85 p. c.....	lb.	.65	.66
Potassium chlorate, crystals.....	lb.	..	nominal
Potassium cyanide, 98-99 per cent.....	ton	3.50	3.50
Potassium iodide.....	lb.	.32	.33
Potassium muriate, 80-85 p. c., basis 80 p. c.....	ton	450.00	460.00
Potassium nitrate.....	lb.	.32	.33
Potassium permanganate.....	lb.	2.50	2.75
Potassium persulphate.....	lb.	.92½	.95
Potassium prussiate, yellow.....	lb.	275.00	300.00
Potassium sulphate, 90-95 p. c., basis 80 p. c.....	ton	..	..
Rochelle salts.....	lb.	.10	.12
Salt ammoniac, gray.....	lb.	.17	.18
Salt ammoniac, lump.....	100 lb.	1.10	1.25
Salt soda.....	ton	13.00	14.00
Salt cake.....	ton	7.0	..
Silver cyanide, price depends on silver mkt.....	oz.	46½	48½
Silver nitrate.....	oz.	.03½	.03¾
Soda ash, 53 per cent.....	lb.	.14	..
Sodium acetate.....	lb.	.82½	..
Sodium benzoate.....	lb.	.02	.06½
Sodium bicarbonate, domestic, f.o.b. works.....	lb.	.02½	.04
Sodium bicarbonate, English.....	lb.	.22	.23
Sodium bisulfate.....	lb.	.25	..
Sodium chlorate.....	lb.	..	nominal
Sodium cyanide.....	lb.	..	..
Sodium fluoride, commercial.....	lb.	.01½	.02½
Sodium hyposulphite.....	100 lb.	3.10	3.20
Sodium nitrate.....	lb.	.18	..
Sodium nitrite.....	lb.	..	.06
Sodium peroxide.....	lb.	.05	.06
Sodium phosphate, U. S. P.....	lb.	.55	.77½
Sodium prussiate.....	100 lb.	.85	1.00
Sodium sulphate, liquid.....	lb.	..	.03½
Sodium sulphide, 30 per cent, crystals.....	lb.	.50	.52
Strontium nitrate.....	ton	29.50	29.50
Sulphur, crude, New York.....	ton	2.50	2.70
Sulphur, flowers, sublimed.....	100 lb.	1.95	2.25
Tin, pure.....	100 lb.	1.95	2.25
Tin bichloride, 50 deg.....	lb.	.50	.52
Tin oxide.....	lb.	.25	.27
Zinc carbonate.....	lb.	10½	11½
Zinc chloride.....	lb.	.45	..
Zinc cyanide.....	lb.	.12	.13
Zinc sulphate.....	lb.	.07½	.08

Coal Tar Crudes

Benzol, pure white.....	gal.	\$0.55	\$0.60
Toluol, pure.....	gal.	2.25	3.00

Nylon, pure.....	ton	1.00	1.25
Solvent naphtha, light.....	ton	..	..
Solvent naphtha, heavy.....	ton	..	..
Creosote.....	ton	..	..
Phenol.....	ton	..	..
Phenol, technical.....	ton	..	..

Intermediates, Etc.

Acetanilid.....	lb.	\$9.50	\$9.55
Aniline oil.....	lb.	.25	.30
Aniline, 80 per cent.....	lb.	.10	.12
Benzaldehyde.....	lb.	5.00	7.00
Benzidine.....	lb.	1.90	2.25
Benzoin, technical.....	lb.	10.00	12.00
Beta naphthol, sublimed.....	lb.	1.20	1.25
Chlor benzol.....	gal.	1.35	1.40
Cresol, U. S. P.....	gal.	1.35	1.40
Diphenylamine.....	lb.	.50	1.10
Metaphenylenediamine.....	lb.	1.00	1.70
Naphthalene.....	lb.	.10	.10½
Naphthalene, acid, technical.....	lb.	1.45	1.65
Para toluidine.....	lb.	1.70	1.90
Phenol, drums.....	lb.	.52½	.55
Salicylic acid, bulk.....	lb.	1.20	1.35
Sulphanilic acid.....	lb.	.45	.60

Petroleum Oils

CRUDE (AT THE WELLS)

Pennsylvania.....	bbl.	..	\$2.75
Cornell, Ohio.....	bbl.	..	2.10
Somerset, Ky.....	bbl.	..	2.20
Wooster, Ohio.....	bbl.	..	1.70
Indiana.....	bbl.	..	1.33
Illinois.....	bbl.	..	1.00
Oklahoma and Kansas.....	bbl.	..	1.00
Caddo, La., light.....	bbl.	..	1.00
Corsicana, Tex., light.....	bbl.	..	1.00
California.....	bbl.	.70	.82

LUBRICANTS

Black, reduced, .29 gravity, 25-30 cold test.....	gal.	\$0.11	\$0.14
Cylinder, light.....	gal.	.21	.26
Cylinder, dark.....	gal.	..	.27
Extra cold test.....	gal.	.26	.31
Paraffine, high viscosity.....	gal.	.29½	.30
Paraffine, 100 spec. gr.....	gal.	..	..
Paraffine, .865 sp. gr.....	gal.	.18½	.19

Flotation Oils

(F.O.B. WORKS IN BARRELS)

Pine oil, steam distilled, G. N. S. No. 5.....	gal.	..	.60
Pine oil, destructively distilled, G. N. S. No. 6.....	gal.	..	.48
Pine-tar oil, G. N. S. No. 8.....	gal.	..	.21
Pine-tar oil, double refined, G. N. S. No. 9.....	gal.	..	.22
Pine oil, light, Georgia Pine No. 182.....	gal.	..	.26
Pine oil, heavy, Georgia Pine No. 205.....	gal.	..	.26
Pine tar, thin, G. N. S. No. 14.....	gal.	..	.16
Turpentine, crude, G. N. S. No. 11.....	gal.	..	.35
Hardwood oil, G. N. S. No. 17.....	gal.	..	.15
Creosote, coal tar, neutral, G. N. S. No. 20.....	gal.	..	.14
Creosote, coal tar, acid, G. N. S. No. 22.....	gal.	..	.11½

Vegetable and Other Oils

China wood oil.....	gal.	\$0.11	\$0.12½
Cottonseed oil, crude, f.o.b. mills.....	gal.	.86	..
Lanseed oil, raw.....	gal.	.86	..
Rosin, 280 lb.....	bbl.	6.75	6.80
Rosin oil, first run.....	gal.	.38	.39
Turpentine, spirits.....	gal.	.52	.52½

Miscellaneous Materials

Barytes, floated, white.....	ton	\$2	..
Chalk, light, precipitated, English.....	lb.	..	..
Fuller's earth, powdered.....	100 lb.	2.00	..
Plaster of Paris.....	lb.	..	..
Red lead, dry.....	ton	8.00	12.00
Talc, American, white.....	lb.	.02	..
White lead, dry.....	lb.	..	..

Refractories, Etc.

(F.O.B. WORKS)

Chrome brick.....	net ton	\$110.00	\$120.00
Chrome cement, Grecian.....	net ton	60.00	70.00
Clay brick, 1st quality fireclay.....	per 1000	35.00	40.00
Magnesite, Grecian, dead burned.....	net ton	85.00	90.00
Magnesia brick, (Grecian, 94½% MgO).....	per 1000	40.00	45.00
Silica brick.....	per 1000	40.00	45.00

Ferroalloys

Ferromanganese, domestic, delivered.....	ton	\$155.00	\$165.00
Ferromolybdenum.....	ton	100.00	..
Ferrosilicon, 75-80 p. c. f.o.b. Pittsburgh.....	lb.	2.50	..
Ferrotungsten, 75-80 p. c. f.o.b. Pittsburgh.....	lb.	2.75	3.00
Ferrovanadium, f.o.b. works.....	lb.	2.75	3.00

INDUSTRIAL

Financial and Construction News

Financial

Air Reduction Company, Jersey City, N. J., is incorporated for \$150,000 to manufacture and deal in oxygen, nitrogen and liquid air. The incorporators are C. H. Lewis, Philip L. Nieser, Jersey City, and John R. Turner, Basking Ridge, N. J.

Akron Metal Products Company, Akron, Ohio, incorporated for \$100,000. The incorporators are Herbert E. Lawrence, M. B. Gore, W. C. Tappenden, C. W. Dennett and Thomas Brennan.

Alaska Seaboard Copper Company, Seattle, Wash., incorporated with \$1,000,000 capital by Wm. H. Byington, Jr., J. Henry Denning, W. W. Sweet.

Alcohol Chemical Co., Wilmington, Del. is incorporated with \$100,000 to buy, sell and extract and deal in alum, sulphate and chloride. The incorporators are Cornelius A. Cole, Robert A. Van Voorhis and Arthur R. Oakley.

Alliance Chemical Company, Boston, Mass., is incorporated for \$50,000. The incorporators are Alan A. Clafin, Joseph N. Paradis and Francis G. Hayes.

Alpha Chemical Works, Inc., Bound Brook, N. J., is incorporated with a capital of \$100,000 to manufacture and deal in chemicals and dyes. The incorporators are Rovey von Cleff, George W. Study, New York, and Lester C. Burdett, Fallsdale, N. Y.

American Aniline Products Company, Inc., was recently incorporated with \$500,000 capital in New York State.

Amolin Chemical Company, Lodi, N. J., incorporated with \$25,000 to manufacture and deal in chemicals and fabrics for dress shields, by John Behrens, Hasbrouck Heights, and Harry Lemmermann, Bronxville, N. Y.

Atlas Color Works, Inc., Brooklyn, N. Y., incorporated with \$25,000 to manufacture dyestuffs by F. R. Eicken, C. Zobel, 270 Third Street; P. Zobel, 524 Ninth Street, Brooklyn.

Barnet Burgess Chemical Co., Inc. is incorporated with a capital of \$100,000 to buy and sell and extract and deal in alum, aluminum, silicon and metals of all kinds. The incorporators are Cornelius A. Cole, Hackensack, N. J.; Robert A. Van Voorhis, Jersey City, and Arthur R. Oakley, Pearl River, N. Y.

William Becker's Aniline & Chemical Works, Brooklyn, has increased its capitalization from \$2,000,000 to \$5,000,000.

Belleville Chemical Company, Belleville, N. J., incorporated with \$50,000 to manufacture chemicals.

Brewster Oil Company, Portland, Ore., incorporated with \$500,000 capital to conduct a general business in the production, manufacture and selling of oils, natural gases and other mineral substances. Incorporators, C. F. Tenant, Portland; Elton H. Thompson, Portland, and Frank B. Schofield, Portland.

Brooks Bros. Dyeing Company, Inc., is incorporated with a capital of \$80,000 to carry on the business of dyeing, tinting and coloring. The incorporators are H. A. H. and A. Brooks, Rochelle Park, N. J.

Carbo-Nitrates Company, Wilmington, Del., incorporated with \$5,000,000 to mine coal, lignite, bituminous, etc. Incorporators: J. H. Reid, Sherman, Vt.; George P. Christy, Pittsburgh, Pa.; H. A. Porter, Cranston, Pa., and J. M. Bergman, Avalon, Pa.

Carso Paper Company, Boston and Danvers, N. Y., capital, \$100,000. Incorporators: J. Butler Studley, Newton; Philena E. Gamage, Waltham; Robert Weston, Cambridge, and Elizabeth D. Peabody, Medford.

Cascade Paper Company, Tacoma, Wash., incorporated with \$425,000, by Frank S. Baker, D. van Buren and J. T. S. Lyle.

Chemical Carbon Refining Company, Chicago, Ill., has increased its capital stock from \$25,000 to \$45,000.

The Chemical Refractories Company, Youngstown, Ohio, incorporated with \$10,000 capital by J. B. Kennedy and others.

Commonwealth Mining Company, Spokane, Wash., is incorporated with a capital

of \$1,300,000. The incorporators are M. A. Phelps, J. F. Sexton and C. H. Williams.

Connecticut Steel Corporation, Wilmington, Del., is incorporated with a capital of \$5,000,000 to manufacture metals and articles made from metals. The incorporators are Herbert E. Latzer, Norman P. Coffin and Clement M. Enger.

Consumers Sulphur Company, Inc., Wilmington, Del., is incorporated with a capital of \$1,500,000 to manufacture pyrites, sulphur, gypsum stone, ores, metals and minerals. The representative is H. M. Keith, 17 Battery Place, New York City.

Continental Products Company, Cleveland, Ohio, incorporated with \$35,000 to manufacture paints by M. M. Roche, Maurice M. Murphy, Mary B. Grossman, Alvin L. Buchner and Ival Donahue.

Cosmic Metal, Philadelphia, Pa., is incorporated for \$500,000 to manufacture bearing metals by amalgamation. The incorporators are F. R. Hansell, George H. B. Martin and S. C. Seymour.

Cosmopolitan Oil & Paint Mfg. Company, Cicero, N. Y., incorporated to manufacture and deal in paints and oils. Capital, \$60,000.

Dowling Iron & Steel Company, Boston, Mass., is incorporated for \$20,000. The incorporators are J. M. Martin, George George Blaney, Benjamin F. deCosta and William J. E. Sander.

Eagle Rock Oil Company, Wilmington, Del., is incorporated with a capital of \$500,000 to prospect for oil, petroleum, coal and other minerals. The incorporators are W. F. O'Keefe, George G. Steigler and E. E. Wright, Wilmington.

Elmstrom Leather Company, Boston, Mass., is incorporated with a capital of \$25,000, 450 shares at \$100 each. Directors: Robert M. Elmstrom, 27 Lincoln Street, Boston, president and treasurer; E. L. Elmstrom and H. E. Johanson.

Esmeralda Mines Corporation, New York, incorporated with \$1,000,000 capital to mine copper, gold, silver, etc. Incorporators: Samuel B. Howard, L. H. Gunther and Arthur W. Britton, all of New York.

Eureka Chemical Company, Wilmington, Del., incorporated with \$100,000 capital to manufacture and deal in chemicals.

H. E. Friedrich Chemical Mfg. Company, Westfield, N. J., incorporated with \$10,000 to manufacture and deal in chemicals and drugs by Spencer D. Embree, Harry S. Embree, Westfield, and Richard C. Rice of New Brunswick, N. J.

Federal Dyestuff & Chemical Company, Kingsport, Tenn., offered Dec. 8 to 11, through White & Co., Hanover Bank Building, New York, a limited amount of common stock at \$50 per share. The company owns 200 acres of land at Kingsport and has twenty-nine buildings devoted to the manufacture of dyestuffs and chemicals, the present production being 50,000 tons per year. The company has strong financial backing and is capitalized at several millions.

General Synthetic Company, Newark, N. J., incorporated with \$100,000 capital by Rupert G. Gates, East Orange; Joseph E. Cohen, Michael Silver, Newark. Will manufacture and deal in all kinds of chemicals.

George Strong Harral Company, Inc., Brooklyn, N. Y., incorporated with \$75,000 capital to manufacture soaps, disinfectants, chemicals, by G. S. Harral, Brooklyn; A. Miller and L. F. Skiver of 60 Wall Street, New York.

Hawkeye Leather Company, Des Moines, Iowa, is incorporated with a capital of \$10,000. Louis Panamas is president and T. F. Mansfield is secretary.

Iridescent Dyestuff & Color Company, Inc., Brooklyn, N. Y., is incorporated for \$200,000 to manufacture dyestuffs, chemicals and drugs. The incorporators are H. Audley, H. R. Brown and C. W. Timm, 656 East 228th Street.

Kansas Oil Investment Company, New York, N. Y., is incorporated with a capital of \$25,000 to acquire lands containing oil and gas and to develop the same. The incorporators are Allen P. Hallett, Arthur M. McKnight and Ira T. McKnight, all of New York.

Keystone Dyestuff & Chemical Company, Newark, N. J., incorporated with \$300,000 capital to manufacture and deal in dyes,

acids, chemicals and colors. Incorporators: Edward J. Fuchs, Henry C. Beecher, Newark; Charles J. Justice, Woodhaven, L. I.

M. & M. Oil Burner Company, Spokane, Wash., incorporated with \$100,000 capital by E. C. Moulds, A. B. Moulds, L. R. Stithen, James S. Lane and Alexander Moses.

Marine Oil Company, San Francisco, Cal., is incorporated with a capital stock of \$200,000, 200,000 shares at \$1 each to produce and deal in oil and gas. The subscribers are W. C. Tupper, V. Shaw, W. J. Dinsmore, L. Barneson and M. Syme.

Mars Paper Corporation, New York, chartered in Delaware with \$100,000 capital to manufacture paper and allied products, by Arthur W. Britton, Samuel B. Howard, L. H. Gunther, all of New York.

Massillon Foundry & Machine Company, Massillon, Ohio, capital increased from \$200,000 to \$300,000.

The North American Antimony Smelting Company, Ltd., incorporated in Canada with \$2,000,000, presumably by American interests who recently secured an option on the antimony mines at Lake George, in the St. Stephen consular district.

Oil Fork Development Company, Louisville, Ky., incorporated with capital of \$30,000, divided into shares of \$1 each, to develop oil lands in Eastern Kentucky. The incorporators are C. F. Blakey, Irvin Marcus and Z. Starr.

Pan-American Laboratories, Inc., Wilmington, Del., incorporated to manufacture chemicals with \$50,000 capital.

Passaic Leather Company, Inc., New York City, N. Y., is incorporated with a capital of \$100,000 to manufacture leather, lumber beetle, etc. The incorporators are J. F. O'Neill, Boonton, N. J., and L. H. Healy, 2 Virginia Place.

Petrole Refining Products Company incorporated with \$1,500,000 to manufacture petrol and own oil wells, gas wells, etc. Incorporators: Valentine Robinson, Charles V. Barker, Brooklyn; Armand Lablach, New York.

The Potash Company of Utah, Marysville, Utah, incorporated with \$1,500,000 to develop the alunite deposits in Piute County. The company, it is said, owns more than 500 claims adjoining those of the Mineral Products Company, one of the first potash manufacturers in the United States. The principal place of business of the Potash Company will be at Marysville. The officers named in the articles of incorporation are Don R. Johnson, president; F. B. McCarthy, secretary-treasurer, and C. S. Hammond, director. Other incorporators are Walter W. Byrne, Salt Lake City, and Frank W. Taylor of Philadelphia, head of one of the largest chemical houses in the United States.

The Roe and Stugo Chemical Company, New York City, has been incorporated with a capital of \$10,000. T. Weiranch is a director.

The Royal Oil & Gas Company, Zanesville, Ohio, has been incorporated with a capital of \$35,000.

The Sandusky Forge Company, Sandusky, Ohio, has been incorporated with a capital of \$300,000. J. Barrows, Jamestown, N. Y., is president, M. E. Crow, Elkhart, Ind., is vice-president, and W. H. Collier, Fainesville, Ohio, secretary-treasurer.

The Sanol Chemical Company, St. Louis, has been incorporated with a capital of \$50,000. Incorporators are J. H. Wedemeyer, W. R. Gilbert.

The Seaboard Corporation, Lakewood, N. J., incorporated with \$500,000 to acquire mineral rights and produce oil, gas and mineral substances. Incorporators: John W. Magnall, Joseph R. Norris, Butler, N. J., and Edwin W. Smith, New York.

Silver Bell Mining Company, Spokane, Wash., is incorporated with a capital of \$1,500,000. The incorporators are E. H. Belden, R. F. Blackwell, James M. Kirkpatrick, James C. Eick and H. N. Metzger.

Silver Mountain Mining Company, Spokane, Wash., incorporated with \$1,500,000 capital by W. E. Seelye, Boyd Hamilton and John Hunt Shepard.

Silver Side Mining Company, Salt Lake City, Utah, is incorporated with a capital of \$50,000 to operate mines in the district, Utah county. The incorporators are W. W. Hammel, E. T. Culmer, H. P. Huey, William Holmes and E. H. Roberts.

The Sixty-Six Oil Company, Wichita Falls, Tex., has been incorporated with a capital of \$15,000. The incorporators are T. B. Noble, F. N. Lawton, P. C. Straus.

Smith-Lewis Foundry Company, Elizabeth, N. J., is incorporated with a capital of \$10,000 as a foundry and tool workers. The incorporators are Stephen G. Williams, Kenneth McEwen, New York, and John J. Griffin, East Orange, N. J.

from the North Louisiana fields as fuel. The process to be used is the invention of Charles S. Bradley, well known engineer, of New York City. While it has long been recognized that these ores were of great value, no coal lands are located in the vicinity and this stood in the way of their development.

Maryland

BALTIMORE—A large artificial silk mill is being erected by J. L. & M. Maerkens at Curtis Bay. They formerly operated a plant in Belgium.

BALTIMORE—The Aluminum Ore Company, a subsidiary of the Aluminum Company of America, plans the erection of a bauxite refining plant at Sollers Point, near Sparrows Point, Md., on a large tract of land recently purchased. The plant will cost about \$1,000,000 and will be completed early in 1918. It will be built by the engineering department of the Aluminum Company of America, with C. E. Fox, superintendent of a similar plant of the company at East St. Louis, Ill., in consultation.

ELKTON—The Jessup & Moore Paper Company, which operates the Radnor Pulp Works here, announced that it would erect a bleach mill at a cost of \$500,000.

Massachusetts

HOLYOKE—The Keith Paper Company will erect a larger addition to its plant at Turner's Falls, which will double its capacity. The Ranger Construction Company has the contract.

Michigan

MANISTIQUE—This town is expected to experience quite a boom, as it has been announced that a 50-ton paper mill would be built. L. C. Harmon of Minneapolis, president of the Upper Peninsula Development Bureau and vice-president of the Consolidated Lumber Company, has closed a deal with Twin City financiers making the plant possible. A \$300,000 pulp mill is at present being erected by Francis W. Little and other Twin City financiers on the Manistique River, where they have obtained water rights.

Minnesota

LITTLE FALLS—The Hennepin Paper Company is making the several improvements at its plant, including two new boilers in the boiler house, with Jones self feeders, and a combination cutter. Eight new water wheels will also be installed.

Montana

BOULDER—The East Side Butter Company is erecting a \$60,000 cyanide mill.

LIBBY—J. H. Ehlers of Spokane and M. E. Wilson, a banker of Minneapolis, announced that a \$10,000,000 pulp mill project contemplated for Libby by large pulp makers.

Nebraska

OMAHA—Morris & Company has erected a new fertilizer plant in South Omaha, costing \$40,000. The equipment is being moved in.

New Jersey

MILLVILLE—Plans are reported to have been prepared by the Whittall-Tatum Company for a large glass factory at Millville, to produce glassware for domestic and foreign trade.

New York

NEWBURGH—The Stilson Corporation is erecting an oil refinery here. A generation system patented by William H. Stilson, will be used. The Stilson Company is a subsidiary of the Southern Oil & Transport Company, a \$20,000,000 corporation formed some time ago to merge a number of Mexican oil companies. Mr. Stilson will remove his laboratory from Jersey City to Newburgh.

Ohio

DAYTON—The Lindebach Company has been incorporated with \$10,000 capital to manufacture aniline dyes, as the result of experiments made by the C. A. Kurz Chemical Company. The incorporators are Walter L. Kurz, T. L. Howard, M. E. Bayless, and others.

Oklahoma

BRISTOW—The Continental Refining Company, which recently increased its capital stock from \$1,000,000 to \$1,500,000, will enlarge its refinery so as to refine oil and make all the products of the West, as well as petroleum, and by spring it is expected to have a capacity of 3500 barrels a day.

Oregon

PORTLAND—The Northwest Steel Company will build a \$1,000,000 rolling mill. The Wheeler mill for iron and steel and operation will be extended.

Pennsylvania

ALLENTOWN—The old Allentown Foundry Company has been purchased by D. D. Dery, for a silk plant, and the Bradley Pulverizer Company, manufacturers of pulverizing machinery for reducing refractory materials to powder.

BRISTOL—Plans are prepared for erecting a dye plant on canal opposite cotton bricquery plant. Daniel P. Walters, 53 Wister Street, Philadelphia, owner.

PHILIPSBURG—The Phillipsburg Clay Products Company will manufacture building brick, and later on tile, low-grade fire bricks, etc. They have secured 150 acres of coal and clay lands here and will construct a plant in the spring, the winters being of such a character as to prohibit construction work.

PITTSBURGH—The Burdett Oxygen Company will complete the erection of their Pittsburgh, Pa., plant, at Fortieth Street and Allegheny Valley Railroad, on Dec. 1, 1916, and will be in a position to furnish oxygen to users in the Pittsburgh territory. The Pittsburgh plant is the eleventh plant erected by the Burdett Company in the various industrial centers of the country.

POTTSTOWN—The Eastern Iron & Steel Company has shut down its No. 2 furnace because of the shortage of coke. A new furnace will be erected, to be completed by April 1, 1917.

Rhode Island

PAWTUCKET—The Eureka Dyeing & Bleaching Company is erecting a three-story concrete and wood addition to its plant, which will treble its capacity.

Tennessee

CHATTANOOGA—The chamber of commerce and the city board of commissioners have had under consideration the building of a new wharf, and it was announced recently that no action would be taken until the matter of location of the government nitrate plant had been definitely decided. The committee states that if the nitrate plant is located at Muscle Shoals that a much larger wharf will be needed for the freight shipments here will be much larger.

Texas

EL PASO—Reported W. and C. C. Bush will erect \$50,000 ice plant.

PORT ARTHUR—The Texas Company is erecting thirty-three extra stills to take care of increasing business. The cost is said to be about \$150,000.

Utah

SALT LAKE CITY—If suitable clay can be found in Utah, the Lostout Mountain and the city board of commissioners will establish a factory here within the next year.

SALT LAKE CITY—The Potash Company of Utah, capitalized at \$1,500,000, will develop the alumina and potash deposits south of Utah. The claims adjoin those of the Mineral Products Corporation at Marysville. Shafts will have to be sunk to get the alumina deposits. Some of the interested are Dr. B. H. Payne of San Francisco, Walter W. Byrne of Salt Lake City, Senator Penrose of Pennsylvania, and Harry W. Clarke, eastern railroad director.

SALT LAKE CITY—The Salt Lake Chemical Company, owned by the Diamond Match Company, has completed a six-mile pipe line and will shortly operate its plant at Grants, Tooele County, built to obtain potash from the waters of Great Salt Lake. J. M. Sullivan is in charge of the plant.

Virginia

CHARLOTTESVILLE—The plant of H. E. Young & Company, Inc., will probably start operations April 1, 1917, producing extracts for dyeing, tanning and color making. The machinery is all installed and is expected to turn out 30,000 lb. annually. H. E. Young of Hanover, Pa., is president; J. D. Young of Charlottesville is superintendent and general manager, and R. Delaney of Hanover, Pa., is chief chemist.

PETERSBURG—The du Pont Powder Company is understood to be making a number of experiments at its Hopewell plant at which gun cotton is made, with a view to turning it into a permanent industry after the war. Such products as lead pencils, automobiles and dyestuffs are talked of.

RICHMOND—The Dixie Paper & Pulp Company, recently organized, has taken over the property at the foot of Seventh Street, known as Brown's Island, and is remodeling and enlarging the building. Richmond is growing rapidly into the front as a paper manufacturing center. It is the home of the Standard Paper Company,

the largest concern in the blotting paper field. The Manchester Board & Paper Company and the Albemarle Paper Manufacturing Company, both with large plants. The Richmond Paper Manufacturing Company several years ago sold its brands and is now engaged in the wholesale paper business.

Washington

TACOMA—The Alaska-Endicott Mining & Milling Company, 402 Tacoma Building, Tacoma, Wash., incorporated about a year ago, will develop mining property on William Henry Bay, about 40 miles north of Juneau. A small plant will be installed now with a 30-hp. engine, compressor outfit, etc., the ore being shipped to Tacoma for reduction. They plan the installation of a 100-ton oil flotation plant next year.

TACOMA—The Cascade Paper Company of Tacoma, a new company with \$425,000 capital, expects to erect a paper-making plant in Tacoma. Plans have not yet been fully decided upon. The officers are D. den Bleyker, J. T. S. Lyle and F. S. Baker.

West Virginia

CHARLESTON—The Cabin Creek Refining Company has plans for erecting a \$1,000,000 gasoline refining plant. The company is a subsidiary of the Ohio Cities Gas Company.

CHARLESTON—The new plant of the Roessler & Hasslacher Chemical Company being erected in the Kanawha Valley is expected to be completed by April 1, 1917. About 150 men will be employed at the start. The new buildings cover six or seven acres, about a mile below St. Albans. The company owns 225 acres of land and has plenty of room for future extensions. The representatives of the company now in St. Albans are R. N. Sargent, manager of one of the company's plants at Perth Amboy, N. J.; J. J. Owens, and N. H. Galt. They will have a siding on the Chesapeake & Ohio Railroad.

WHEELING—The Whitaker-Glessner Company will construct a \$200,000 warehouse on a site recently purchased. The work will be done by the Foundation Company and the Riverside Bridge Company. A permit has also been granted to the La Belle Iron Works for the erection of a gas producing plant to house gas tanks. The plant is now under construction and will cost \$18,000.

WHEELING—Work on the new plant of the United Zinc & Smelter Company is progressing rapidly. The foundations for the furnaces and most of the buildings have been completed.

Wisconsin

MILWAUKEE—The Herman Zohrlaut Leather Company will be operated by the Pfister & Vogel Leather Company. New additions will be made to the Zohrlaut plant, to cost \$15,000.

MILWAUKEE—The Progressive Metal & Refining Company will build a two-story addition to its plant at Barclay and Washington Streets.

Wyoming

WORLAND—A large beet-sugar factory is contemplated for the Big Horn Basin section by a new company called the Wyoming Sugar Company, capitalized at \$1,000,000. The principal stockholders are said to be Joseph R. Eccles and Charles E. Kaiser of Ogden, Utah; Using, a New York banker; J. L. Williams of New Mexico; George Crosby, Billings, Mont.; and Herman B. Gates, state treasurer of Wyoming. The Great Western Sugar Company is now constructing a plant at Lovell in the same district.

Canada

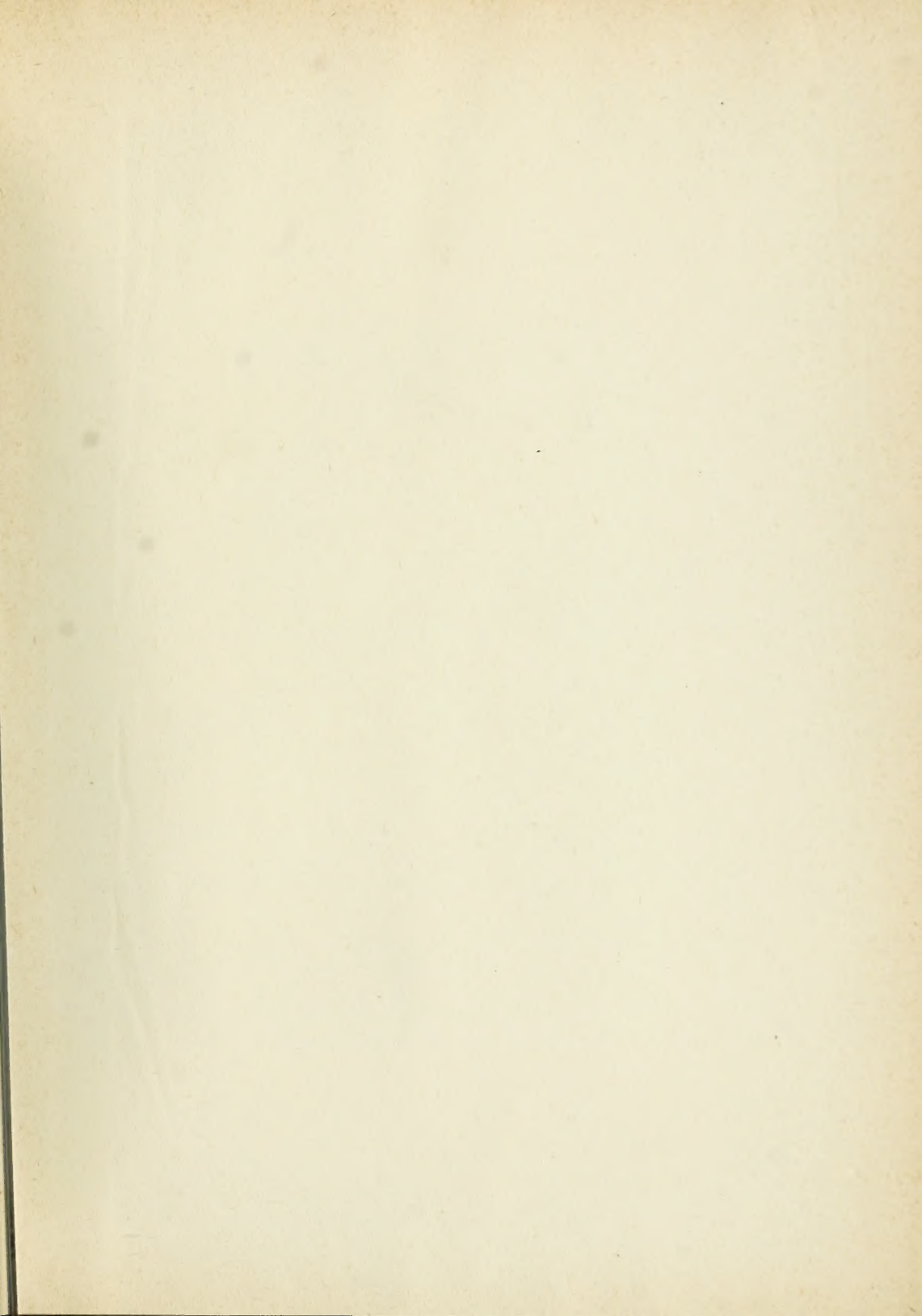
FREDERICTON, N. B.—Fraser's, Ltd., St. Johns, N. B., contemplate the erection of a pulp mill to be operated by a separate company with \$4,000,000 capital. The Nashwaak Pulp & Paper Company, which bought the mills and lands of the Partington Pulp & Paper Company, will cut 20,000 cords of timber this winter.

QUATSONS, ALBERTA—The Colonial Pulp & Paper Mills, Ltd., will erect a sulphite mill here with a capacity of 120 tons a day. The first unit will have a capacity of 60 tons. It is expected that the plant will be completed within a year.

Korea

Shipment of the material for the new battery of 50 Wulputte By-Products Coke Ovens to be erected by Mitsubishi Goshi Kaisha at Kienjho, Korea, is rapidly being completed by the company, Otto Coking Company, Inc., New York. The new ovens will furnish the coke for the blast furnace plant now being erected for the Mitsubishi Company at Kienjho.





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